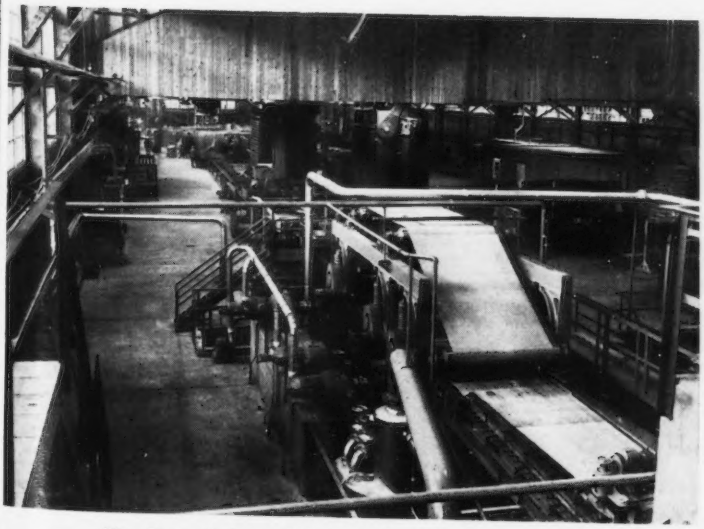
Forest Products Journal

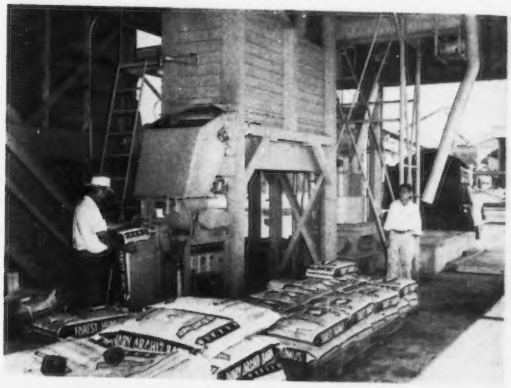
NAT'L MEETING TECH. PROGRAM—p. 7-A

This Issue: Special Report on Uses for Bark

Drilling-Mud Additives, a Specialized Use



Hardboard from Mill Residues Including Bark



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FOREST PRODUCTS JOURNAL

Vol. IX, No. 4 April, 1959

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Filtering disposal-plant effluent through redwood bark improves the bark as a fertilizer, make effluent less harmful.

Commercial Uses for Redwood Bark Dust ..... *R. W. Miller* 22-A
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Chemicals from Bark ..... *E. Farber* 25-A
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Utilizing Bark at a Medium-Size Mill: Processing and Merchandising Bark Products ..... *E. P. Ivory and P. Field* 28-A
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In the All-Board process, large amounts of bark can be used without adverse effect on board properties.

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Horticultural Applications for Bark and Wood Fragments ..... *O. R. Lunt and B. Clark* 39-A
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IMPORTANT FPRS DATES

June 5, 1959: Upper Mississippi Valley Section Meeting, Albert Lea, Minn.

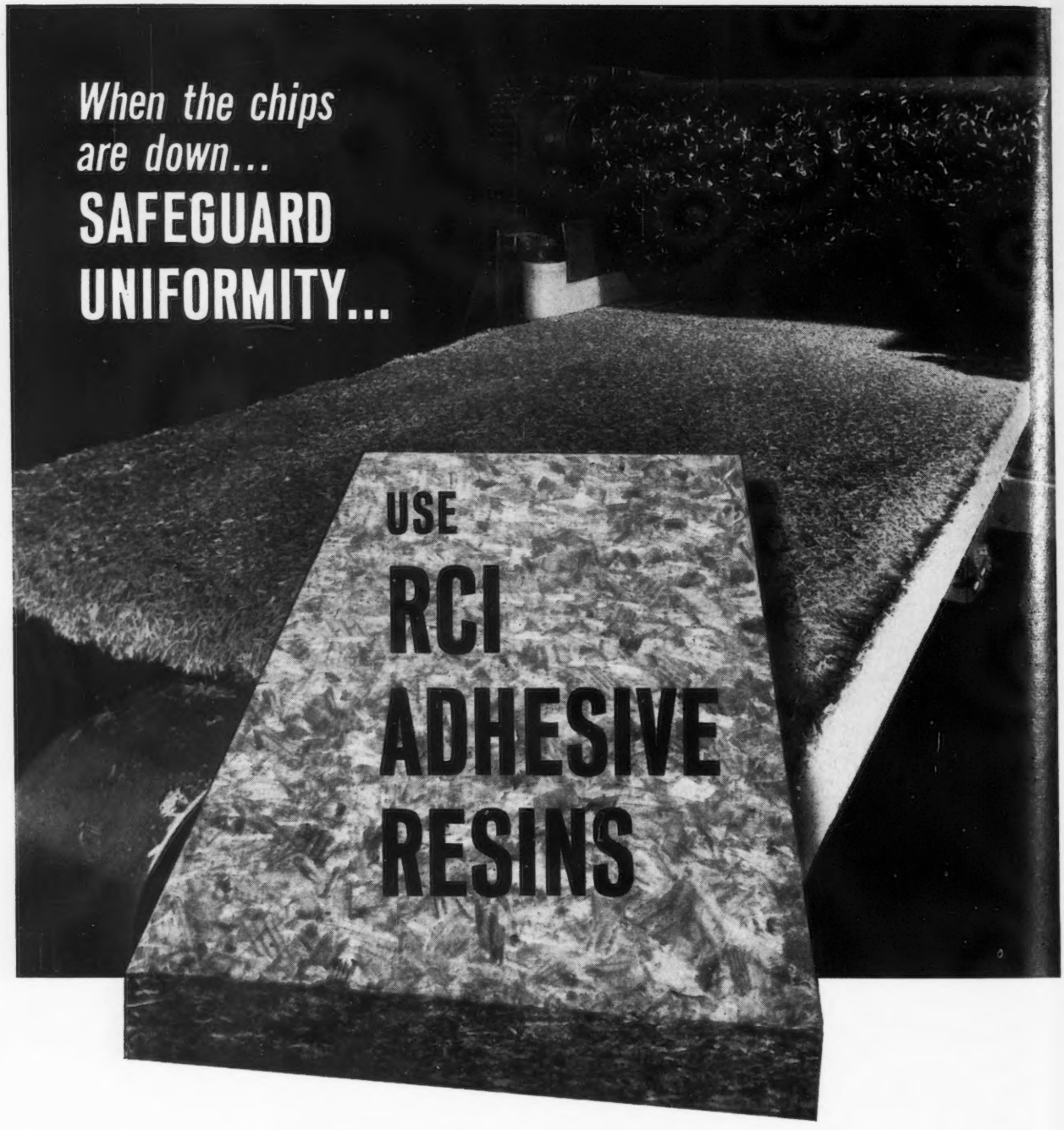
June 28–July 3, 1959: Thirteenth National Meeting, San Francisco, Calif.

Sept. 10–12, 1959: Joint A.S.M.E., A.I.Ch.E., Pacific Northwest—Inland Empire Section Meeting, Portland, Ore.

Oct., 1959: Mid-South Section Meeting, Lufkin, Texas.

Oct. 29–30, 1959: Northeast Section Meeting, Worcester, Mass.

Late Oct. or early Nov., 1959: North Central Regional Meeting, Chicago, Ill.



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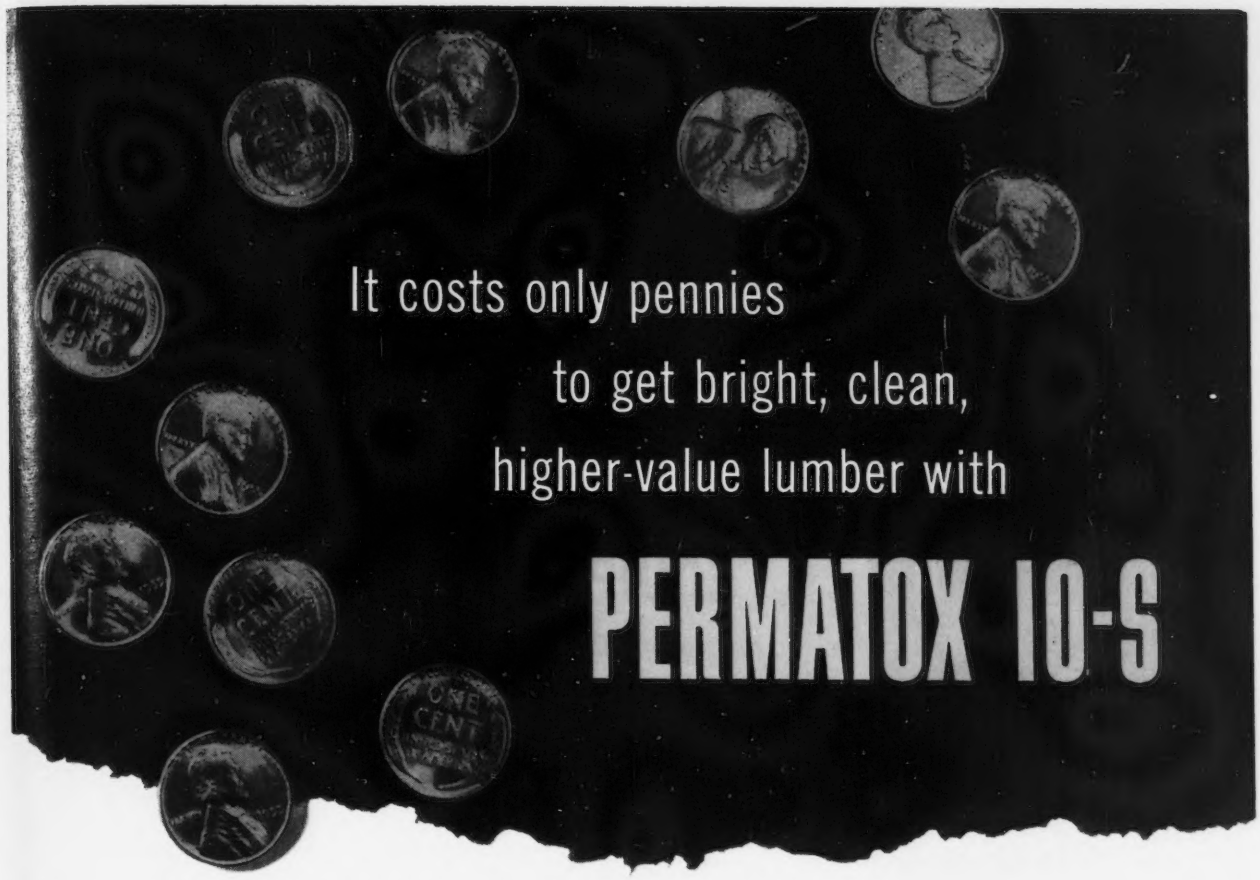

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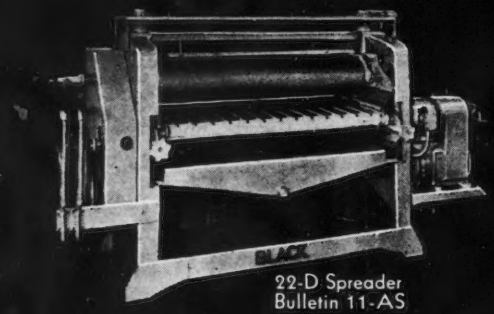
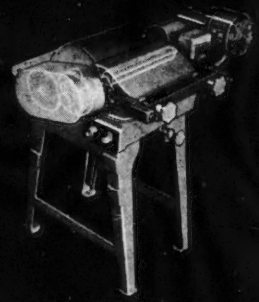


22-D Spreader
Bulletin 11-AS



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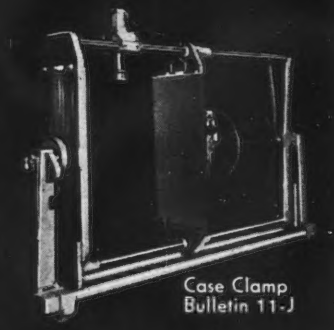

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Bulletin 11-J

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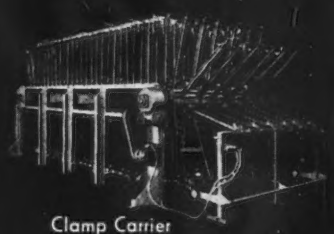

Clamp Carriet
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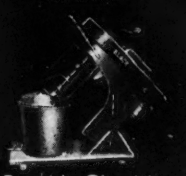

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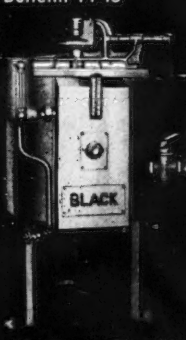

No. 700 Series Glue Heater
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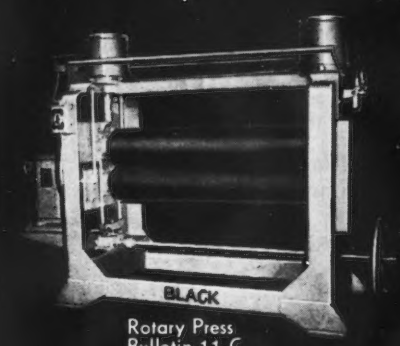

Rotary Press
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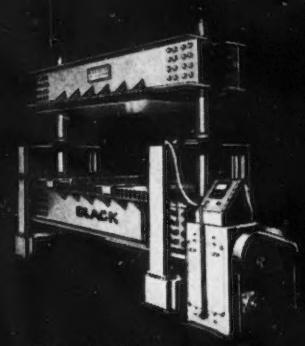
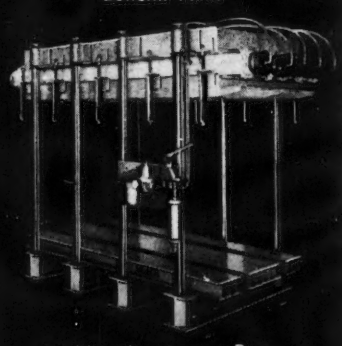


Motorized Laminating Press
Bulletin 11-E



Air Hose Laminating Press
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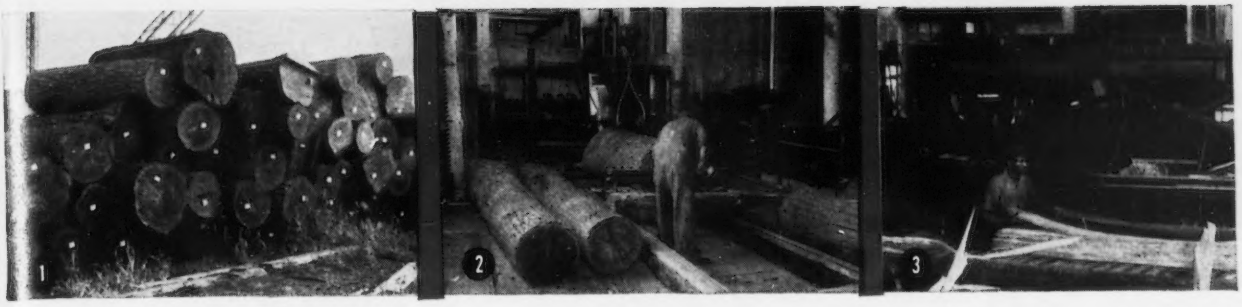

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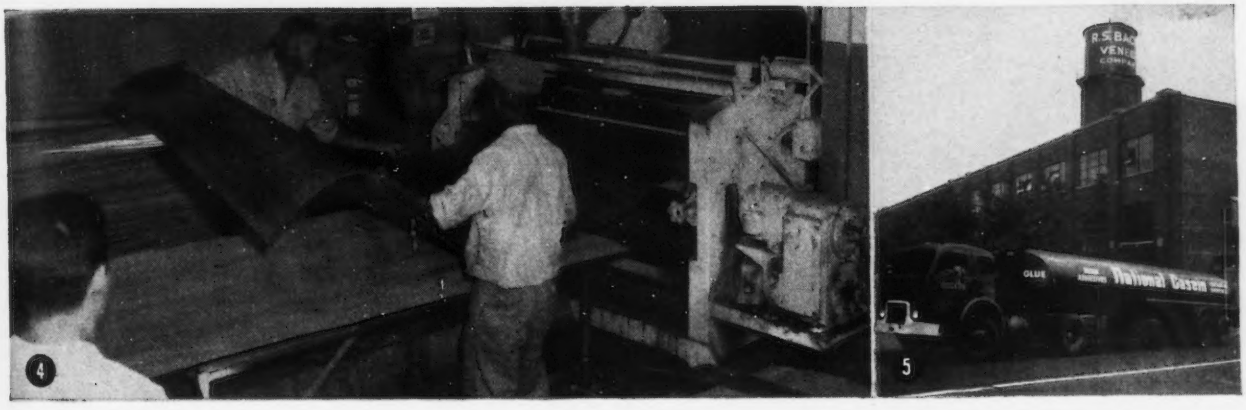

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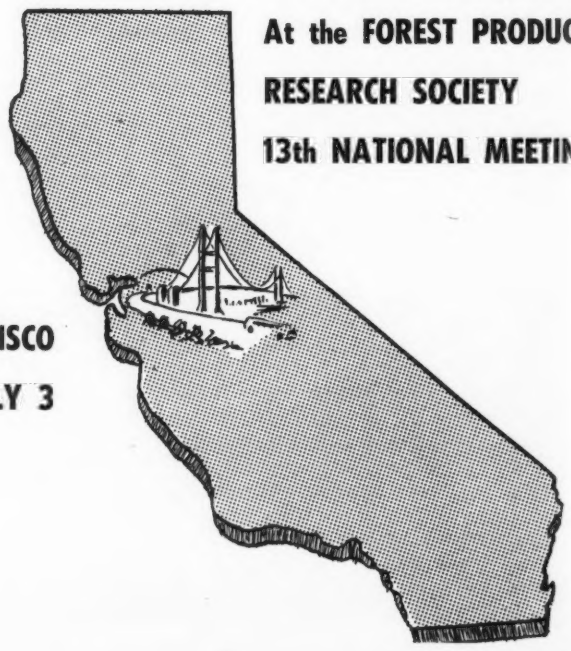

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FPRS News-Digest

Gen. James N. Gavin to Address FPRS National Meeting Luncheon

Technical Program 90% Formed for San Francisco

PARTICLE BOARD

Monday, June 29, 8:45–11:45 a.m.

Manufacturing Problems, by E. S. Johnson, N. C. State College, Durham, N. C.

VENEER & PLYWOOD

Monday, June 29, 8:45–11:45 a.m.

Potential of Western Hardwoods for Veneer & Plywood. Peter H. Koehler, Timberline, Inc., Crescent City, Cal.

Motion Picture Studies of Veneer-Cutting at the Cellular Level, Lawrence Leney, U. of Missouri, Columbia, Mo.

Lathe Check Formation in Douglas Fir Veneer, E. H. Collins, Weyerhaeuser Timber Co., Longview, Wash.

New Performance Test for Interior Plywood & Application to Panels Containing White Pocket. Robert Ripley, Douglas Fir Plywood Assn., Tacoma, Wash.

Heating Douglas Fir Veneer Bolts—Does It Pay? G. H. Atherton & J. B. Grantham, Ore. Forest Products Research Center, Corvallis, Ore.

WOOD MACHINING

Monday, June 29, 8:45–11:45 a.m.

Stresses in Circular Saws. Cecil Best, Calif. Forest Products Lab., Richmond, Cal.

Performance Characteristics of Combination Circular Sawblades on Radial Arm Saws. J. L. Lubkin & C. W. McMillin, American Machine & Foundry Co., Stamford, Conn.

Cross-Cutting Research with Power Chain Saw Teeth. J. W. Oehrli, McCulloch Corp., Los Angeles, Cal.

Design of Production Woodworking Machinery, by A. M. Kvalheim, Kvalheim Machine Co., Petaluma, Calif.

GLUES & GLUING

Monday, June 29, 2:00–4:30 p.m.

The Technology of Elastomeric Adhesives—C. B. Heming, U. S. Plywood Corp., Brewster, N. Y.

Elastomeric Adhesives—Their Application in Forest Products Industry. C. C. Booth, C. P. Hancock & J. M. Hine, Borden Chemical Co., Bainbridge, N. Y.

New Approach to Lumber Laminating. George G. Marra, Washington State Institute of Tech., Pullman, Wash.

Finger Jointing at High Moisture Contents. R. A. Currier, Ore. Forest Products Research Center, Corvallis, Ore.

Status of Our Present Knowledge of Adhesion in Wood. J. E. Marion, Forest Products Laboratory, Richmond, and Arne Wissing, Stockholm, Sweden.

CHEMICAL UTILIZATION

Monday, June 29, 2:00–4.30 p.m.

Influence of Extractives on the Seasoning Stain of Redwood Lumber. A. B. Anderson, Eric Ellwood and Eugene Zavarin, Forest Products Laboratory, Richmond, Cal.

Distribution of Dihydroquercetin in Douglas-Fir and Western Larch Wood. J. A. F. Gardner and George M. Barton, Forest Products Laboratories of Canada, Vancouver, B. C.

Wood and Bark Products Used in Oil Well Drilling. R. W. Miller & Wm. G. Van Beckum, Pacific Lumber Co., San Francisco, Cal.

A Close Look at Charcoal Production Costs for Kiln Operation. Carl Arbogast and Charles E. Boldt, Lake States Forest Experiment Station, Marquette, Mich.

WOOD PRESERVATION

Monday, June 29, 2:00–4:30 p.m.

Development of Fire-Retardants for Wood Treated with Oil-Type Preservatives. H. M. Tobey, Chapman Chemical Co., Memphis, Tenn.; R. M. Gooch & D. L. Kenaga, Dow Chemical Co., Midland, Mich.

Flame-Spread Measurements on Wood-Base Materials Using Radiant Panel Test Method. Daniel Gross, U.S.D. Commerce, Washington, D. C.

Prevention of Deterioration of Wood in Contact with Iron. J. E. Marian, Calif. Forest Products Lab., Richmond, Cal. and Arne Wissing, Swedish Forest Products Lab, Stockholm.

Building Codes as they Relate to Forest Products, by John Fies, NLMA, San Francisco.

LOGGING

Tuesday, June 30, 9:30–11.30 a.m.

Small Log Harvesting in Douglas Fir

Continued, Next Page

CAMBRIDGE, MASS., April 13—It was announced early this week, by FPRS president W. J. Eason, and national meeting chairman, R. H. Berry, that the principal guest speaker for the forthcoming 13th national meeting would be Lieutenant General James M. Gavin, USA (Ret.), executive vice president and director of the famed Arthur D. Little, Inc., research institution.

Gen. Gavin, best known until his retirement in March, 1958, as Chief of Plans and Operations, Plans and Research, and Research and Development of the Dept. of Army, is currently concentrating in the fields of management research and administration; as well as heading-up further development of A. D. Little regional offices.

Gen. Gavin received his B.S. degree from the U. S. Military Academy, at West Point, in 1929, and served at numerous U. S. Army posts here and abroad until his retirement in 1958.

Author of "War and Peace in the Space Age," and "Airborne Warfare," Gen. Gavin has in addition published many technical articles. He is a member of the American Rocket Society, and of the Council on Foreign Relations.

The General's address before FPRS will be given at the Official Luncheon, hotel St. Francis in San Francisco on Tuesday, June 30.

Region. W. A. Davies, Ore. State College, Corvallis, Ore.
Bacterial Attack of Pine Logs in Pond Storage. Eric Ellwood & B. A. Ecklund, Calif. Forest Products Lab., Richmond, Cal.
Timber Sale & Logging Contract Writing. Emanuel Fritz, Berkeley, Cal.
Log Supply & Handling Problems in a Northern Calif. Operation. R. C. Andree, U. S. Plywood Corp., Redding, Cal.
Salvage Logging. John Miles.

WOOD DRYING

Tuesday, June 30, 9:30–12 Noon

Shrinkage & Elastic Properties of Ray Tissue as Factors Contributing to Difference Between Radial & Tangential Shrinkage of Calif. Black Oak. A. P. Schniewind, Calif. Forest Products Lab., Richmond, Cal.
Air Circulation in Forced Air Drying of Lumber. D. M. Post, U. of Fla. Gainesville, Fla.
Solvent Seasoning of Tanoak. A. B. Anderson & W. B. Fearing, U. of Calif., Berkeley, Cal.
Calculating Internal Stresses in Wood. R. L. Youngs & C. B. Norris, Forest Products Lab., Madison, Wis.
Control of Sugar Pine Brown Stain with Sodium Azide. R. E. Stutz, Western Pine Assn., Portland, Ore.

WOOD FINISHING

Tuesday, June 30, 9:30–12 Noon

Fire-Retardant Latex Intumescent Coatings. Richard Drubel, Dow Chemical Co., Midland, Mich.
Alcohol & Solvent Resistant Furniture Finishes. Robert L. Skov, Hercules Powder Co., Wilmington, Del.
Polyurethane Wood Finishes. L. L. McGinnis, E. I. du Pont de Nemours & Co., Wilmington, Del.
New Finishes for Wood—Polyester Types. Neil Estrada, Reichhold Chemicals, Inc., San Francisco, Cal.
Development in Color Finishing for Plywood—Precolor Sealing System & Rollgrain Printing. P. E. Leary, Wolverine Finishes Corp., Grand Rapids, Mich.
Epoxy Resins for Wood Finishing, by H. W. Howard, Shell Chemical Corp., New York City.

LUMBER MANUFACTURING

Tuesday, June 30, 2:45–5:15 p.m.

Place of the Sawmill in an Integrated Forest Operation. L. W. Hooker, Mich. College of Mining & Tech., Houghton, Mich.
Place of the Sawmill in a Predominately Douglas Fir Integrated Forest Operation. D. E. Lane, B. C. Forest Products Ltd., Vancouver, B. C.
Sorting Logs to Improve Sawmilling. H. I. Winer, Yale Univ., New Haven, Conn.
Role of the Sawmill in Whole Log Utilization. N. T. Shelton, Diamond Match Co., Chico, Cal.

PACKAGING

Tuesday, June 30, 2:45–5:15 p.m.

What's New in Pallet Assembly. E. G. Stern, Va. Polytechnic Institute, Blacksburg, Va.
Pallet Bins for Harvesting Apples in Pacific Northwest. S. W. McBirney, USDA, Wenatchee, Wash.
Spiral Wrapping Machine for Panel Products. R. C. McRae, Coast Iron & Machine Wks., Tacoma, Wash.
Engineered Wood Cellulose Cushioning for Packaging. C. E. Swanson and A. J. Withoff, Wood Conversion Co., St. Paul, Minn.

LUMBER MANUFACTURING & WOOD DRYING

Wednesday, July 1, 9:00–11:30 a.m.

Some Problems in Effectively Using Results of Research in Lumber Manufacturing & Drying. C. F. Anderson, Winton Lumber Co., Minneapolis, Minn.
Segregation of Lumber for Kiln Drying. K. O. Smith, Jr., Cheney Lumber Co., Tacoma, Wash.
Recent Research Results & Their Application in the Lumber Industry. Leif Espenas, Ore. Forest Products Research Center, Corvallis, Ore.
A Sawmill Man Looks at His Own Drying Operation. E. P. Ivory, Ivory Pine Co., Dinuba, Cal.
Automated Sorting & Stacking of Green Lumber in a Small Mill. Charles Herstrom, Powell River Co., Ltd., New Westminster, B. C.

GLUES & GLUING

Wednesday, July 1, 9:00–11:30 a.m.

Panel discussion: "How Can the Plywood Industry Improve Control of its Glue-Bond Quality?"
Responsibility of the Trade Assn. to the Industry. R. C. Raymond, Douglas Fir Plywood Assn., Tacoma, Wash.
The Adhesive Companies' Role in Assuring Quality Glue Bonds. J. M. Hine, Borden Co., Seattle, Wash.
Quality Control—A Production Responsibility. K. K. Graves, Georgia–Pacific Corp., Portland, Ore. The Plywood Manufacturer's Unique Responsibility. H. W. McClary, Simpson Logging Co., Shelton, Wash.
Quality Control—A Customer's Privilege. L. A. Patronsky, Timber Engineering Co., Albany, Ore.

INDUSTRY–EDUCATION

Wednesday, July 1, 9:00–11:30 a.m.

The Lumber Industry's Stake in Education, R. H. Gloss, Timber Engineering Co., Washington, D. C.
An Architect Uses Wood. Henry Hill, San Francisco, Cal.
Education Sells Wood Structures—A Company's Experience. G. A. Williams, St. Paul & Tacoma Lumber Co., Tacoma, Wash.
Objectives of NLMA's Education Program. John I. Zerbe, NLMA, Washington, D. C.

MERCHANDISING

Thursday, July 2, 9:00–11:30 a.m.

"Wood's Promotion—Whose Responsibility?" Viewpoint of the Lumber Retailer, Albert B. Ratner, Forest City Material Co., Cleveland, O.
What Wholesalers are Doing to Promote Wood, by L. J. Fitzpatrick, L. J. Fitzpatrick Lumber Co., Madison, Wis.
Viewpoint of Lumber Manufacturer. S. A. Bishop, Union Lumber Co., San Francisco, Cal.
Panel Discussion (above three authors)
Presentation: Hitchcock's Wood Working "Award of Merit" Robert Bolinder, Wheaton, Ill.

CHEMICAL UTILIZATION

Thursday, July 2, 9:00–11:30 a.m.

A Summary of the Status of Pyrolysis. R. C. Sproull, Philip Morris, Research Department, Richmond, Va.
Preparation and Properties of Hydroxymethyl furfural. J. F. Harris, L. L. Zoch, and J. F. Saeman, U. S. Forest Products Laboratory, Madison, Wis.
Pulping Characteristics of Sawdust Chips Made by a Coarse Feed Saw. J. S. Martin, U. S. Forest Products Laboratory, Madison, Wis.
Laboratory Evaluation of Nitric Acid Pulping. Ross P. Wither and Henry Captein, Crown Zellerbach Corporation, Central Research Department, Camas, Wash.
Separation of Lignosulfonates from Carbohydrates in Aspen Spent Sulfite Liquors by Means of Ion Exchange. Irwin A. Pearl and Donald L. Beyer, Institute of Paper Chemistry, Appleton, Wis.

GENERAL

Thursday, July 2, 9:00–11:30 a.m.

Process of Converting Sawdust to an Efficient Fertilizer Carrier/Soil Conditioner. Eduard Farber, Washington, D. C.; R. R. Hind, Pope & Talbot, Inc., & Ferseolin Corp., San Francisco.
Merchandising Aspects of "Non-Com". R. H. Bescher, Koppers Co., Inc., Pittsburgh, Pa.
Effect of Formation Variables on Properties of Wood Particle Moldings. T. J. Patterson, Georgia-Pacific Corp., Hillsboro, Ore.; & J. D. Snodgrass, Ore. Forest Products Research Center, Corvallis, Ore.
Continuous Carbonization & Briquetting of Wood Residue. E. E. Dahlman, Charcoal Industries, Inc., Conway, S. C.; & W. R. Smith, USDA, Asheville, N. C.

Study of Means for Reducing Checking of Douglas-Fir Plywood Without Overlays or Sealers. Armin Elmendorf, Elmendorf Research, Inc., Palo Alto, Cal.

WOOD COMPOSITION BOARD

Thursday, July 2, 2:00–4:30 p.m.

. Great Challenge to the Particle Board Industry—Develop Standards. H. W. Guenther, Pope & Talbot, Inc., Oakridge, Ore.

Bending Strength of Wood Particle Board Under Long Term Loading. Eugene Bryan, Calif. Forest Products Lab., Richmond, Cal.

Stability & Strength of Oak Particle Boards as Influenced by Particle Shape and Inclusion of Wax. Bruce Heebink, Forest Products Lab., Madison, Wis.

Durable Adhesives for Particle Board. John Hine, The Borden Co., Seattle, Wash.

QUALITY CONTROL

Thursday, July 2, 2:00–4:00 p.m.

Methods & Machines for Quality Control of Forest Products. O. J. Black, I. B. M. Corp., New York, N. Y.

Usefulness of Surface Texture Measurements for Quality Control. D. A. Stumbo & J. E. Marian, Calif. Forest Products Lab., Richmond, Cal.

San Francisco Hotels

FPRS convention attendees may make reservations at the following San Francisco hotels. "S" means single rate, "D" means double, and "T" means twin. Numbers in parentheses indicate blocks from the St. Francis Hotel, FPRS convention headquarters.

Chancellor (1), 433 Powell St.; D $8.50, T $9.50.

Clift (2), Geary & Taylor Sts.; S $13–$21, T $16–$23.

Drake–Wiltshire (1), 540 Stockton St.; S $10, D $12, T $15.

Fielding (1), 386 Geary St.; D $10.

Franciscan (1), 350 Geary St.; S. $7, D $9, T $12.

Golden State (2), 114 Powell St.; D $6.50–$7, T $8–$8.50.

Manx (1), 225 Powell St.; S $7–$9, D $9–$11, T $10–$12.

Plaza (1), Post St., T $12–$14.

St. Francis (Headquarters), Union Square; S $11–$22, D $13–20, T $16–$25.

Sir Francis Drake (1), Sutter & Powell Sts.; S $10–$15, D $12–$17, T $15–$20.

Stewart (1), 351 Geary St., D $8–$10, T $10–$18.

Stratford (1), 242 Powell St.; S $5, D $6–$7, T $7–$8.

75 Companies Sponsor "Paul Bunyan" Cruise

San Francisco. Seventy-five wood industry suppliers are sponsoring the traditional Paul Bunyan social hour at the Thirteenth Forest Products Research Society National Meeting, according to Byrne C. Manson, California Redwood Association, and FPRS Paul Bunyan Chairman. This year the traditional event will be a cocktail cruise around scenic San Francisco Bay on Tuesday evening, June 30. The cruise will start from the Fisherman's Wharf area, San Francisco, returning to the same point two hours later. Sponsoring firms as of May 1 are:

American Cyanamid Co., New York, N. Y.
American Manufacturing Co., Tacoma, Wash.
American-Marietta Co., Seattle, Wash.
American Sheet Metal Works, Inc., Portland, Ore.
F. E. Barnett Co., Eureka, Calif.
The E. J. Bartells Co., San Francisco, Calif.

Continued. Next Page

PRE-REGISTRATION FORM

THIRTEENTH ANNUAL MEETING—FOREST PRODUCTS RESEARCH SOCIETY

San Francisco, California **June 28–July 3, 1959**

Return to: Forest Products Research Society, P.O. Box 262, Burney (Shasta County), California

(PLEASE PRINT OR TYPE)

Name _____
(Last Name) (First Name) (Middle Initial) (Mrs.)

Address _____

City, Zone, State _____

Company or Organization _____

REGISTRATION (Includes Paul Bunyan Cocktail Cruise on San Francisco Bay)

		Enter Amount Below
FPRS Member	$12.00	$_____
Non-Member	14.00	_____
Ladies	6.00	_____
Children (no charge) Name _____ Age_____		
Name _____ Age_____		
FPRS Official Luncheon, per ticket	4.50	_____
FPRS Banquet, per ticket	8.00	_____
Ladies' Fashion Show Luncheon, per ticket	2.75	_____
Ladies' Sightseeing Tour of City, per ticket	3.50	_____
	Total Registration Fees	$_____
Hotel and Type Room desired: _____	Total Hotel Deposit (see Hotel Registration above)	$_____
_____	Total Amount Enclosed	$_____

Make checks payable to: F.P.R.S. 1959 National Meeting Committee

75 Company Sponsors of "Paul Bunyan" Cruise Entertainment, cont'd

J. H. Baxter & Co., San Francisco, Calif.
Behr-Manning Corp., Troy, N. Y.
Black Bros. Co., Inc., Mendota, Ill.
Booth Kelly Lumber Co., Springfield, Ore.
The Borden Co., New York, N. Y.
C. K. L. Machinery Co., Oshkosh, Wis.
The Carborundum Co., Niagara Falls, N. Y.
Catalin Corp. of America, New York, N. Y.
Chain Belt Co., Berkeley, Calif.
Chapman Chemical Co., Memphis, Tenn.
Cheney Stud Co., Tacoma, Wash.
Cleworth Publishing Co., Cos Cob, Conn.
Coe Manufacturing Co., Painesville, Ohio
Collins Pine Co., Chester, Calif.
The Crossett Co., Crossett, Ark.
Crown Zellerbach Corp., San Francisco, Calif.
Decar Plastic Corp., Middleton, Wis
Diamond Gardner Corp., Chico, Calif.
Douglas Fir Plywood Assn., Tacoma, Wash.
The Dow Chemical Co., Midland, Mich.
Durez Plastics Division, Hooker Electrochemical Co., North Tonawanda, N. Y.
Fairhurst Lumber Co., San Rafael, Calif.
Fibreboard Paper Products, Inc., San Francisco, Calif.
Chas. A. Fowler Co., San Francisco, Calif.
Gamble Bros., Inc., Louisville, Ky.
Hitchcock Publishing Co., Wheaton, Ill.
R. Hoe & Co., Inc., New York, N. Y.
Ivory Pine Co., Dinuba, Calif.
Koppers Co., Inc., Chemical Division, Pittsburgh, Pa.
The Lilly Co., High Point, N. C.
C. M. Lovsted & Co., Inc., Seattle, Wash.
Mater Machine Works, Corvallis, Ore.
Mattison-Greenlee Service Corp., Rockford, Ill.
Mereen-Johnson Machine Co., Minneapolis, Minn.
Michigan-California Lumber Co., Camino, Calif.
Monsanto Chemical Co., St. Louis, Mo.
Moore Dry Kiln Co., No. Portland, Ore.
National Casein Co., Chicago, Ill.
National Lumber Manufacturers Assn., Washington, D. C.
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Nicholson Manufacturing Co., Inc., Auburn, Wash.
Nickey Bros., Inc., Memphis, Tenn.
Orton Machine Co., San Francisco, Calif.
Pacific Manufacturing Co., Santa Clara, Calif.
Peter Cooper Corp., Gowanda, N. Y.
The Pacific Lumber Co., San Francisco, Calif.
Poinsett Lumber Manufacturing Co., Pickens, S. C.
Potlatch Forests, Inc., Lewiston, Idaho
Protection Products Manufacturing Co., Kalamazoo, Mich.
Rader Pneumatics, Inc., Portland, Ore.
Rees Blow Pipe Manufacturing Co., Berkeley, Calif.
Reichhold Chemicals, Seattle, Wash.
Roddiscraft, Inc., Arcata, Calif.
Scott Lumber Co., Burney, Calif.
Setzer Forest Products, Sacramento, Calif.
Simonds Saw & Steel Co., Fitchburg, Mass.
Ralph L. Smith Lumber Co., Anderson, Calif.
Southwest Lumber Mills, Phoenix, Ariz.
Standard Oil Co. of California, San Francisco, Calif.
Sumner Iron Works, Everett, Wash.
Tarter Webster & Johnson, Inc., San Francisco, Calif.
Union Oil Co. of California, Los Angeles, Calif.
U. S. Plywood Corp., New York, N. Y.
U. S. Plywood Corp., Redding, Calif.
Washington Iron Works, Seattle, Wash.
West Coast Lumbermen's Assn., Portland, Ore.
Weyerhaeuser Timber Co., Tacoma, Wash.
Wilco Machine Works, Memphis, Tenn.
Winton Lumber Co., Martell, Calif.

The "Madcaps," Decca Recording Stars.

The "Belle Aires," lovely ladies of son

Varied Social Program Planned for San Francisco

Van Beckum

San Francisco. A full round of social affairs has been planned for the enjoyment of those attending the Forest Products Research Society Thirteenth National Meeting in San Francisco June 28–July 3, according to Bill Van Beckum, Chairman of the Social and Hospitality Committee.

Registrants and their families arriving Sunday, June 28, will have an unique opportunity to participate in a colorful, typically California wine tasting party. A number of excellent California wines will be sampled. Soft drinks will be provided for children. The party, provided by the host Northern California Section, is scheduled for 6:00 to 9:00 p.m. at the St. Francis Hotel and will give people the opportunity to meet old friends and gain new ones.

The traditional Paul Bunyan Social Hour, to be held Tuesday evening, June 30, is planned as an evening cocktail cruise around scenic San Francisco Bay. Seventy-five wood industry suppliers have made this social hour possible. Two cruise boats, Harbor King and Harbor Queen, have been reserved. Registrants and their families will embark from the Fisherman's Wharf area in San Francisco at 5:30 p.m. Tuesday for the two-hour cruise. Later, the registrants can make up their own dinner parties and enjoy some of the famous eating spots in the Fisherman's Wharf area or in other parts of San Francisco.

The main social event of the meeting, the gala FPRS party night, is scheduled for Wednesday evening. The evening will start with a no-host cocktail hour followed by the dinner and excellent entertainment. During the cocktail hour, partygoers will be entertained by the Melodairs Trio, popular vocalists who encourage requests and group singing as they stroll through the crowd. Entertainment at the close of the dinner will be supplied by Glen Hayward, comedy Master of Ceremony who provides a magic and ventriloquist act; the Bell Aires, three lovely ladies of song whose repertoire ranges from current Broadway hits to operatic and old time favorites; and the Madcaps, a sensational musical and comedy act who are recording stars at Decca. At the close of the entertainment, dance music will be provided by a nine-piece orchestra.

Jane Mullally, leader of Melodairs Trio

Glen Hayward, Master of Ceremonies.

Meet the Ladies Committee. Back row (left to right): Ruth Smith, Lillian Ericksen, Dorothy Ellwood, and Louise Smith. Front row (left to right): Co-chairmen Marie Roth and Barbara Kuhn, Liz Pratt and Doris Dickinson. Right: Our co-chairmen discuss a delightful feature of the program.

Plans For FPRS' Distaff Side Announced

Monday's program includes a get-acquainted Kaffeeklatsch in the morning and a Scenic Bus Tour of the city that afternoon. The following day, a Continental Breakfast will precede a tour of some of the city's loveliest shops. This is designed to give a behind-the-scenes glimpse of such exciting shops as I. Magnin (advertised in Harpers and Vogue), Gump's (fabulous Jade collection), and Podesta Baldocci (America's most famous florist).

The Canterbury Hotel's Garden Court, a veritable oasis in the city, has been reserved for a Luncheon Style Show on Wednesday noon.

Special arrangements have been made for a tour of historic Jackson Square, the world's most unique decorative center. These buildings, once the bustling vortex of San Francisco trade in the Gold Rush Days, have been restored to be the elegant wholesale showrooms of more than 70 firms displaying fabrics, wallpapers, furniture, floor coverings, decorative accents, and art treasures from across the world.

Attempts have been made to leave sizable "chunks" of time so that ladies can do some shopping or sight-seeing on their own. It may be a trip to Chinatown, a ride on a cable car, or a visit to the Mission Dolores. Golden Gate Park, with its planetarium and aquarium, and Fleishacker Zoo, including swimming pool and playground, will appeal to the children and adults alike. The breath-taking view from hilltops or skyrooms will not soon be forgotten.

Gray Line schedules bus tours for children. Reliable baby-sitters are available.

Complimentary tickets will be issued to registrants for the Kaffeeklatsch, Continental Breakfast and Tour of Shops, and the Decorators' Tour of Jackson Square. Tickets may be purchased for the Style Show and Conducted Bus Tour at that time.

The Oasis Room in the St. Francis Hotel, reserved as Hospitality Headquarters for the ladies during the entire week, will be available for relaxing, meeting friends, or freshening up.

In addition to the events planned for them especially, wives will join their husands at the Sunday Wine Tasting at the St. Francis Hotel, the Paul Bunyan Cocktail Cruise on the bay, the Official Luncheon on Tuesday, and the Dinner Party Wedenesday evening.

LADIES PROGRAM

Time	Event	Cost
Sunday, June 28		
1:00–8:00 pm	Registration—St. Francis Hotel	$6.00
5:30–8:30 pm	Wine Tasting	Guests of Northern California Section
Monday, June 29		
9:30	Kaffeeklatsch—Georgian Room—St. Francis Hotel	Complimentary ticket
1:15–5:00 pm	Conducted Scenic Bus Tour	$3.50
Tuesday, June 30		
9:15	Continental Breakfast and Tour of Shops	Complimentary ticket
Wednesday, July 1		
12:00	Luncheon and Fashion Show Canterbury Hotel, Garden Court	$2.75
Thursday, July 2		
10:00–12:00	Decorators' Tour of Jackson Square	Complimentary ticket

Some Tips from the Convention Bureau on Climate and Dress in San Francisco

In June and July when the city is enjoying its own private brand of air conditioning, the average temperature during the day is 65°; at night around 53°. Rain is most unlikely, but fog is a frequent evening visitor. San Francisco women favor lightweight wool suits and dresses and small hats, because of the breezes from the bay. Small furs, as well as hats and gloves, are frequently in evidence. It would be wise to include a dark silk basic dress in your wardrobe for the highly possible extremely warm day. A lightweight wrap is essential.

White shoes are rarely worn in San Francisco. However, if you are visiting friends down the peninsula or across the bridge in Marin County, you may choose to bring your light cottons and white shoes. A few miles from San Francisco makes a big difference; the temperature may climb into the 90's.

Technical News

A.I.W.E. Conducting Membership Requirements Survey

The membership committee of the American Institute of Wood Engineering is conducting a survey of forestry school officials and of its members, as an aid in establishing membership requirements for the professional society. This activity is considered an important function of the new society, for membership requirements in a professional society serve to define the profession which that society represents.

For some years forestry school officials have been wrestling with the problem of gaining agreement on, and standardizing curricula in wood or forest products technology, utilization, or engineering. As a first step in its survey the committee studied the catalogs of those schools that offer professional training in this field. They found no well defined, consistent pattern among the various schools.

From this study, however, it was possible to set up a skeleton of study areas that are considered basic to a good "wood tech" education. The basic sciences that underly the professional education can be classified as biological studies of wood, physical and chemical studies of wood, and wood engineering. In the applied area, graduates are expected to have a knowledge of wood processing and the wood using industries, and a limited background in forestry.

The committee proposes that A.I.W.E. set up minimum basic credit hour requirements in each major study area. A total of 32 semester hours of specialized course material is suggested as the minimum required of a graduate with a bachelor's degree. It further proposes that a 10-year transition period be provided, during which certain substitutions in course material are to be permitted. This provision is included to permit time for modification of curricula to meet the standard pattern.

The proposal further permits substitution of experience for education in some of the more applied subjects, and for the establishment of a junior grade of membership for students and others who have not yet gained full membership status.

The results of the survey will be reported at the national meeting of A.I.W.E., to be held on June 28, 1959, in San Francisco.

FPRS National News

Society's 1958 Finances Audited

Dr. Fred Dickinson, member, in the absence of the chairman of the Budget and Finance committee, W. L. Irwin, met with other members of the Executive Board and with the Society's permanent accountants during the January board meeting in Madison to examine FPRS' finances. The Operating Statement and Balance Sheet are presented.

NOTICE

The Constitution of FPRS provides that "Voting shall not be restricted to the names submitted. Twenty-five voting members may file with the Executive Secretary within 30 days after notification of the action of the nominating committees, the name of an eligible candidate for any elective office for which they are entitled to vote. The name of such candidate shall be placed on the ballot. Further, any voting member may vote for any eligible member of his own choice for any elective office by inserting the member's name on the ballot."

FOREST PRODUCTS RESEARCH SOCIETY OPERATING STATEMENT
FOR YEAR ENDED DECEMBER 31, 1958

Cash in Banks and Savings and Loan Shares, January 1, 1958			$ 11,321.86
Income:			
1960 Membership Dues	$ 106.00		
1959 Membership Dues	5,612.13		
1958 Membership Dues	46,663.59		
1957 Membership Dues	147.00	$52,528.72	
Dues Collected for Sections		6,047.00	
Publication Income		31,318.89	
Services to Sections		668.20	
Dividend Income		287.00	
Other Income		76.14	
Executive Office Building Contributions		38,805.50	
1958 Nat'l. Meeting Adv. from CY 1957		1,000.00	
1958 National Meeting		13,372.39	
Total Income			144,103.84
Total Operating Income			$155,425.70
Expenditures:			
Central Office Expenses:			
Salaries	$34,663.78		
Supplies, equipment, furniture, Internal Rev., Retirement Ins. Program, rent, postage, telephone, telegraph, utilities, insurance and miscellaneous services	12,544.70		
Staff travel	1,718.82	48,927.30	
Executive Board Expense		217.80	
Executive Office Building		47,264.64	
Membership Dues Paid to Sections		5,315.00	
Membership Campaign		831.02	
Membership Directory		825.00	
Publication Expense		35,722.88	
1958 National Meeting		11,621.68	
1959 National Meeting Advance		1,000.00	
Total Expenditures			$151,725.32
Cash in Banks		$ 500.38	
Savings and Loan Shares		3,200.00	
Total December 31, 1958			3,700.38

FOREST PRODUCTS RESEARCH SOCIETY BALANCE SHEET 12/31/58

Assets

Current Assets:			
Cash and Savings & Loan Shares		$ 3,724.56	
Northwest Airlines Credit Card Deposit		425.00	
Post Office Mail Deposit		145.69	
Accounts Receivable		2,716.64	
Postage Stamps		264.00	
National Meeting Advance		1,000.00	
Supplies and Membership Material		1,997.80	
Annual Proceedings and Journals		1,000.00	
Total Current Assets			$11,273.69
Fixed Assets:			
Executive Office Building	$47,264.64		
Less Allowance for Depreciation	945.29	46,319.35	
Executive Office Building Lot		10,070.60	
Furniture and Equipment Inventory	$ 9,122.41		
Less Allowance for Depreciation	3,384.11	5,738.30	
Total Fixed Assets			62,128.25
Total Assets			$73,401.94

Liabilities

Current Liabilities:		
Accounts Payable	$ 873.62	
Prepaid Membership Dues	5,718.13	
Membership Dues Payable to Sections	732.00	
Total Liabilities		$ 7,323.75
Net Worth		$66,078.19
Total Liabilities and Net Worth		$73,401.94

Candidates for FPRS National Offices Announced

Candidates for executive board and 1960 national nominating committee have been announced by Ralph H. Bescher, chairman of the 1959 national nominating committee.

Dr. E. S. Harrar, current President-Elect will automatically become president in June, succeeding W. Jeter Eason. Candidate for the office of President-elect is Raymond H. Berry, v. p. and general mgr., Scott Lumber Co., Burney, Calif. Candidate for the office of vice-president is W. L. Irwin, Manager of Poinsett Lumber & Mfg. Co., Pickens, S. C.

James L. Love, Pres., Love Wood Products of Texas, Diboll, Texas, has been nominated for the office of South-Central Regional Board Member.

Walton R. Smith, Chief, Div. For. Util. Research, Southeastern Exp. Sta., U.S.F.S., Asheville, N. C., has been nominated for the office of South-East Regional Board Member.

Eight persons nominated (four to be elected) for the 1960 national nominating committee are: Herbert Fleischer, U. S. Forest Products Lab.; John Grantham, Oregon Forests Products Lab.; G. Maurice Hill, Drexel Furniture Co.; Col. J. H. Jenkins, Canadian Forest Products Lab.; W. L. Lear, Crossett Co.; Arthur Muschler, Edw. Hines Lumber Co.; E. H. Merritt, Ericsson-Merritt Co.; and O. Harry Schrader, U. S. Plywood Co.

BUSINESS TRENDS

Lumber Consumption . . . last year totaled 37,088,000,000 bf, or 0.1% above 1957 but 9% below 1956.

Factory-Built Homes. A nationwide survey by the Home Mfgrs. Assoc. discloses that production reached an all time high of 110,080 "brand name" homes in 1958, an increase of 18% over 1957. HMA stated that it accounted for 11% of all homes started in U. S. Ohio led in no. of mfgd. homes, followed by Illinois, Pennsylvania and Indiana.

Revolutionary Charcoal Plant, using sawdust in a continuous process has been announced by Consolidated Carbon Co., Port Kells, B.C. Process is claimed to be first to permit mass production

of charcoal on a continuous basis, replacing the "batch" method.

National "Wood Information" Center . . . has been set up in Washington at NLMA to provide editorial research material, photographs, background information and references on wood and lumber products for the nation's press.
—NLMA Newsletter

Wood Finishes. A 2-year program to educate retail salesmen on wood finishes has been announced by the Nat'l. Paint, Varnish & Lacquer Assoc. Objective is to give all personnel the selling facts and features of various finishes and how to care for them. A recent survey revealed that to most homemakers Finish simply means color; 80% had never been told about protective features.
—VENEER Newsletter

House Competition. Mobile home business is shifting into high gear. Industry produced 46,000 home trailers in 1949 . . . reached 130,000 in 1958. Three million people now live in house trailers.
—Housing Trends

PROMOTE WOOD—IT'S GOOD!

NLMA president Robert M. Ingram before a recent meeting of the West Coast Lumbermen's Assoc. called for stepped-up advertising-merchandising of lumber and wood products at the regional and local level, by each of the 17 federated associations and member companies.

The chief executive said the lumber industry must make this one of the cardinal points in a "comprehensive 10-year plan of product and industry improvement." Steps must be taken to "assure the end-user of wood the fastest, most economical, most efficient distribution channels we can possibly develop; perfect new products and services that are right for the times; and find new uses for existing products." "To make our dollars count," he said, "we must forge an endless chain of effort from the mill through our associations, through the National Wood Promotion Program, through the wholesaler and retailer," to the ultimate consumer.

National "Wood Council" Organized

Representatives of 29 lumber and wood products groups with diversified background met in Palm Springs, Cal., Feb. 12, 13 to organize the Council, composed of associations who are *not* now members of NLMA but whose cooperation is needed in the overall wood industry united-front promotion.

Elected chairman was John D. Leland, v. p. Long Bell Lumber Div. of International Paper Co., and secretary, Brewster Terry, director Intra-Industry Div., NLMA. Purposes of the Council are:

1. Clearing house for exchange of information regarding problems of mutual interest to members.
2. Coordination of promotional activities.
3. Continuing critical appraisal of progress and extent of promotion.
4. Advisory re: new programs.
5. Develop wood promotion programs.

Among the Associations . . .

The 13th annual meeting of the **National Wooden Pallet Mfgrs. Assoc.** will be held at the Sheraton-Park hotel in San Francisco, June 28–30, their first on the coast. An expanded trade promotion program, development of larger markets for pallet containers and flat pallets, research and development are among subjects to be discussed.

Members of the **American Inst. of Timber Const.,** at their 7th annual meeting at Boca Raton, Fla., inducted as new president, Ward Mayer, founder and chmn. of the bd. of Timber Structures Inc. Frank Hanrahan is Secretary and Executive v.p.

National Wooden Box Assoc., Barr Bldg., Wash. 6, D.C. has released a new film, "Reusable Wooden Containers," which demonstrates the economies in handling and storage using specially designed wooden containers.

Changes, Mergers, Expansion

The Johns-Mansville Corp. has started production at its new $12,000,000 insulating board plant at Klamath Falls, Ore. The plant will employ 125, using as raw material lodgepole pine, first big commercial use of this species in Oregon.

Puget Sound Pulp and Timber Co. of Bellingham, Wash., has a $400,000 program to expand by-products production. First step is a large evaporator for obtaining concentrated lignin from spent liquor. Lignin is being used increasingly as a roadbinder to form a hard surface. Later a new spray drier will be installed to produce powdered by-products. The concentrate, "lignosite" is used for adhesives, leather tanning, oil well drilling compounds, and other chemicals.

Mater Machine Works, Inc., Corvallis, Ore., has doubled its sawmill manufacturing facilities with the acquisition of additional space adjacent to the present plant. New space is to be used for building Mater "Packaged Automation Mills," said to be the only completely turn-key mills, including engineering, construction, automation and putting into operation, in the U. S.

American Marietta Co., Adhesive, Resin and Chemical Div., has changed the name of its former Special Products Dept. to "Industrial Sales & Marketing Dept." Territories have been revised with individual emphasis being directed toward specific industries. The Dept. handles products for the composition board, timber laminate, door, mineral wool and other fields. Manager is Earl T. McCarthy, FPRS N'West membership chairman.

Francis H. Snyder & Associates, New Milford, Conn., has been reorganized as a corporation. Mr. Snyder continues as pres. and Bd. Chmn., and Lewis C. Wallace has been named v. p. The research and development firm, active in the chemical, pulp, paper and plastics field is also working on development of new processes for chemical exploitation of wood residuse.

Fifty-Seven Participate in Log Grading Conference

On April 8 through 10, some 57 men participated in the Log Grading Conference held by the College of Forestry, U. of Idaho, at Moscow, Ida. Representatives from industry, state and federal agencies, and schools came from California, Oregon, Washington, B.C., Montana, Utah and Idaho.

Factors that determine log grades, and principles of grading were stressed, as were factors determining log quality. Learning how to grade logs was coupled with discussions of economic objectives, and benefits from present practices. Instruction was under the direction of George H. Jackson, Western Log Grader, U.S.F.S., aided by reps. of Western Pine Assoc., and the several schools.

SECTIONS in the NEWS

"Wood Fabrication" Theme of Upper Mississippi Meet, June 5

The Upper Mississippi Valley section will hold its Spring meeting at Albert Lea, Minnesota, the afternoon and evening of June 5, according to Section chairman Paul Lane, and program chairman, Walter Wallin. The afternoon will be devoted to plant tours of Page & Hill Homes Co., and Rilco Laminated Products Co. There will be a Paul Bunyan hour from 4:00–5:00 followed by Dinner. The evening will be devoted to a panel discussion of lamination, prefabrication, structural plastics and home construction ideas. This is also "guest nite" to introduce benefits of FPRS membership to others; so be sure to bring at least one guest, the section suggests.

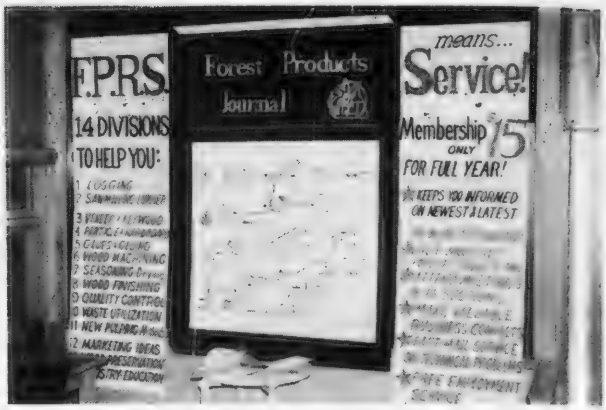
Nine FPRS Sections Appoint Education Committees

One of the more important projects which FPRS has undertaken in recent years has been the preparation and promulgation of "Careers" literature through its Industry-Education division, and sub-committees to be established in each of the Society's 14 Sections. To date, 9 such committees have been established to coordinate their efforts with those of the national Division and the National Lumber Manufacturers Association, Washington, D.C., underwriters of the program.

The career booklet, entitled "Opportunities Unlimited," is now available, singly or in quantities, through Mr. John I. Zerbe, Mgr. Specifications and Standards Dept., NLMA, who heads up this project for his organization.

Composition of the sub-committees in FPRS sections is as follows:

1. **Pacific N'West.** Dr. R. W. Wellwood, U. of B. C., H. D. Erickson, U. of Washington, and Chmn., W. I. West, Oregon State College
2. **Rocky Mountain.** Harry E. Troxell, Colorado State U., Ft. Collins, Chmn.
3. **Upper Mississippi.** W. B. Wallin, U. of Minnesota; and Howard E. Olson, Timber Products Chemical Co., Chmn.
4. **Midwest.** Dwight Bensend, Iowa State College; John Reno, Pacific Lumber Co., and Jack Koellisch, Wood & Wood Products, Chmn.
5. **Mid-South.** Arne Kemp, S. F. Austin State College; D. M. Fisher, Jr., Bradley-Southern Div.; Tom Orth, Kirby Lumber; and Wm. C. Hopkins, L.S.U., Chmn.
6. **Great Lakes.** Aubrey E. Wylie, Mich. State U., Chairman.
7. **Ohio Valley.** Robert Allen, National Casein Co., Chairman.
8. **Northeast.** William T. Nearn, Penn State U., Chairman.
9. **Southeastern.** D. B. Richards, Alabama Poly.; J. B. Huffman, U. of Fla.; Jack Hamilton, U. of Georgia; and R. H. Page, U.S.F.S., Chmn.



FPRS MEMBERSHIP BOOTH at recent Southern Pine Association Exhibit held at New Orleans. Booth was manned by Prof. Bill Hopkins of L.S.U., assisted by Mark Lehrbas, U.S. Forest Service, and chairman of the Mid-South membership committee. National membership chairman T. S. Veazey visited the Exhibit during his U.S. membership swing.

FPRS 1959 "New Membership" Drive Launched

Tony S. Veazey, Jr., FPRS National membership chairman, in an "around the U. S." trip to confer with officers and membership chairmen of our 14 Sections, mid-April, announced plans to break-thru the barrier of 4,000 members and subscribers during this calendar year.

Noting that the Society had some 423 discontinued members in 1958, and that its total membership had decreased by 65, to 3,262 on Jan. 1, 1959, Veazey proposed both a large-scale membership organization plus a "program for action" in the immediate future.

In his travels to St. Paul, Madison, Grand Rapids, Buffalo, Charlotte, New Orleans, Los Angeles, San Francisco and Seattle, Veazey discussed establishing Section quotas of new members by states and sections, reviewed current membership activities, agreed on personnel and organization for the drive, discussed possible "Guest Nites" sponsored by Sections in principal cities and set up target dates for the completed effort.

Emphasizing the need for a "grass roots" approach under the complete direction of our local Sections, Veazey said, "the basic objective is to bring more management men as members, and more companies and supporting members to support our program. Experience has shown that Section meetings are the best source of new members," hence emphasis on "Guest Nites."

Midwest Section Takes Initiative

Concurrently with Mr. Veazey's midwest visit, the Midwest Section announced its schedule of four guest nites to be held in the area during May. According to Wm. A. Kluender, Chairman, and R. W. Archambault, Membership chm., "Our Section will sponsor several guest nites as part of a program to step-up membership in the Society. Many potential members need only a friendly, welcoming hand to initiate participation. Won't you invite one of these people to join you." Meetings were held at Chicago, May 5; Madison, May 12; Oshkosh, May 13; and Clinton, Iowa, May 19.

Ole Anderson, Sec.-Treas. of our Pacific N-West section has been making an "every member bring a member" campaign pay-off in new members in Southern California. To date his efforts have resulted in 10 new members.

Alan Miller, Mgr. of AFPI, Denver is our new membership chairman in the Rocky Mountain Section. Recently he distributed literature and spread the gospel at a clinic of sawmillers in Wyoming. He is off to a good start, backed by enthusiastic chairman, Bob Bader.

Robert Gill, Peter Cooper Corp., Buffalo, and membership chairman of our N. E. Section has a great plan in the works to cooperate with a leading wood industry publication to invite its subscribers in the greater N. E. area to participate in FPRS as well. The national office is preparing a new membership brochure to be used for this purpose.

. . . and so the story goes with "Operation Break-thru, 1959." We'll have more to report next month. Meanwhile won't you exert your influence to gain a new member soon? Thanks.

NAMES in the NEWS

Carl A. Rishell, retired V. P., Timber Engineering Co., Washington, D. C., is writing a monthly column, "Wood Tech" for Furniture Design and Mfg. magazine.

Among those present at the organization meeting of the National Wood Council, were FPRS members **Chic Rinehimer,** founder of the Architectural Woodwork Institute, and **Perry Acuff,** president of Woodwork Institute of California.

Dr. **Leopold F. Bornstein,** for 16 years v. p. and technical director of Synvar Corp., has been named general mgr. of the Plastics Div. of National Polychemicals, Inc., Wilmington, Mass., and v. p. of the parent company. Dr. Bornstein, an authority in the plastics industry, is a member and author of FPRS.

J. D. Bronson, of the Boise-Cascade Corp., was recently elected president of the 12-state Western Pine Association, succeeding **A. B. Hood** of the Ralph L. Smith Lumber Co.

Jack B. Keck has been named Clinton factory manager for Curtis Cos., Inc., Clinton, Iowa. He will also be responsible for operations in Lincoln, Neb., and Lafayette, Ind.

James S. Mathewson, seasoning specialist at the U. S. Forest Products Lab., Madison, has retired after 41 years of service. He has been a frequent contributor to the JOURNAL.

Looking ahead to the 1960 National Meeting at Montreal, Canada, is this group, which held its second steering committee meeting in the historic city recently.

Standing (left to right) are: E. A. Thompson, Canada Creosoting Co., Montreal, past Eastern Canadian Section chairman; R. F. DeGrace, Canadian Institute of Timber Construction, Ottawa, Ontario, ECS secretary–treasurer; and G. S. Billington, Moore Dry Kiln Co. of Canada, Brampton, Ontario, ECS chairman.

Seated are D. K. Saunders (left) Saunders Brothers, Westbrook, Maine, Northeast regional board member and general chairman of the 1960 meeting; and P. R. L. Sage, Architectural and Construction Specialties, Montreal, ECS trustee.

Shakeproof, Ill. Tool Works, Latest Supporting Member

The latest addition to FPRS' 100 Company Supporting Members is Shakeproof, Division of Illinois Tool Works, at Elgin, Ill. Designated representative to the Society from Shakeproof is F. K. Knohl.

Shakeproof is one of eight divisions or subsidiaries of Illinois Tool Works, which serve the woodworking and metalworking industries. Two of these subsidiaries are located in England and Canada. The basic Illinois Tool Company was founded in 1912 and later developed the Shakeproof lock washer, which is the basic product for the Shakeproof Division.

Shakeproof today makes engineered fasteners. Among its developments are the first tooth-type lock washer, the first pre-assembled screw and lock washer, and the first thread-cutting screw for self tapping. Others are the first pre-assembled nut and lock washer, and the self-drilling screw for wood. This last was introduced in January, 1958.

Some of the other Illinois Tool Works' divisions are: Tool and Machine Division, Chicago; and Power Tools Division, Elgin, Ill.; and the Calinoy Division, Los Angeles.

FPRS looks forward to a long and mutually-profitable association with Shakeproof, in improving the standards, technology, and university of modern fastenings in the forest products industries.

Wood Machining Div. to Visit Calif. Cedar Products Co. During National Meeting

A special feature of FPRS Wood Machining Division activities will be a visit, on Thursday, July 2, to Stockton, Cal. During the past several years, this company has carried on an extensive research program in wood machining with emphasis on circular saws. Faced with a problem of higher product output from a given material input, its investigations led to saws much thinner than normally used, and producing much less kerf. This, in turn, led to development of a tandem ripsaw unit to replace the gang ripsaw commonly used. This machine compared with standard practices permits a 10 per cent increase in product from a given amount of raw material.

In charge of the tour will be Mr. Charles Berolzheimer, v. p. and director of research of California Cedar Products Co. Those interested in attending, should register at S. F., Monday morning, June 29.

NEW PRODUCTS *and Literature*

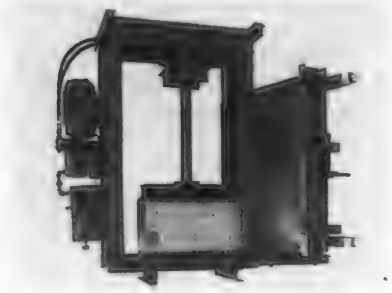
Auto Panel Feeder

A top loading panel feeder for continuous, high-speed sanding has been announced by the Cardwell Mach. Co., Franklin & 19th Sts., Richmond, Va. Panels feed from the bottom of the stack, automatically; no need to stop for loading. Speeds of 200 fpm are said possible.

NEW PRODUCTS, CONT'D.

New DuPont Plastic Film

Production of Type R polyvinyl fluoride film has begun at Buffalo, N. Y., and limited, development quantities are available from the Film Dept. Designed for outdoor application, the new film is said to show promise as a protective laminate. In photo above, plywood covered with film was exposed for 3,000 hours in weatherometer. Wood painted with a conventional finish, right, was exposed for 506 hours in same machine.



New, Small, Wood Shaving Press

A new press for baling wood shavings into compact bales of 60 to 100 lbs. is announced by Consolidated Baling Machine Co., 195 Sixth St., Brooklyn, 15, N. Y. Press is all-steel, hydraulic, high pressure machine, operated by inexperienced help. Chamber is 16 x 30 x 48-in. deep; 5 hp motor.

Reichhold Plyophen 1880 Announced

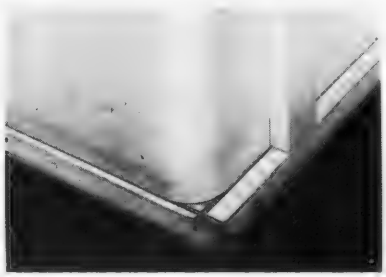
To answer the need for a low-cost room temperature adhesive which produces water-resistant bonds, Reichhold Chemicals, Inc., has developed Plyophen 1880 which, when used with Catalyst 1684, is said to produce a satisfactory bond at temperatures as low as 70° F merely by applying some pressure, such as clamps, for a period of 16 to 24 hours. Where temp. is 100° F a bond may be had in 4 hours. The modified resorcinol resin is lower in price than straight resorcinol. Write Reichhold, Inc., White Plains, N. Y.

New Particle Board Resin

A new, high solids, urea-formaldehyde resin for particle board production has been announced by Catalin Corp., One Park Ave., N. Y. City. It features low viscosity and low free formaldehyde as compared with conventionl high solids ureas. Known as Resin 841, it is designed for multiplaten, horizontal and vertical extrusion processes. Used with liquid accelerators 7078 and 7074 the resin cures faster with longer assembly time.

Kirk & Blum Dust Control Catalog

Sixty plant installations are illustrated in a new 52-page Dust & Fume Controls Systems Catalog published by Kirk & Blum, Cincinnati 9, Ohio. Special sections detail centrifugal collectors and unit collectors, with complete specs.

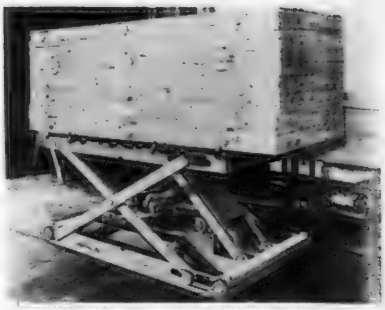


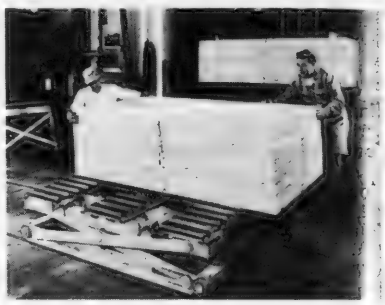
New "Fashionwood" Design

A patent approval for 4 notches cut in Weytex (Weyerhaeuser) hardboard forming the back of a Fashionwood (Curtis Cos.) cabinet; the bending of the sheet to form rounded corners; and grooving into the frame into which the sheet fits, has been awarded.

New Portable Debarker

A new portable debarker is being produced by Morbark Co., it was reported recently. The machine uses a floating cutterhead. It handles pulpwood lengths from 48 to 100 inches and diameters from 3 to 15 inches. Capacity is from 3 to 5 cords per hour depending on species and peeling conditions. Price is $3,950 fob. in the United States. More information is available from Morbark Portable Debarkers, Box 5, Winn, Mich.





New Hydraulic Lift Table

United Products Co., 3001 N. Stat[illegible], Tacoma, has introduced a self-co[illegible]tained hydraulic lift table, 40 in. wi[illegible] and 76 in. long, with lifting height [illegible] 43 in., collapsing to 9 in. Feature [illegible] the UPCO lift is that load is lifted [illegible] center, not on cross arms. Capacity, 5,000 lb. plus overload factor. Catalog available.

Swivel Tong Line Socket

A new socket, used with tongs in shovel loading, has been developed by Electric Steel Foundry Co., 2141 N. W. 25th Ave., Portland. It was designed to reduce wear of tong line and increase safety factor. Fitting is heat treated manganese steel. Replaces eye splices.

Vibrating Screen Separators

Southwestern Eng. Co., 4800 Santa Fe, Los Angeles, 58, has published a new bulletin describing its vibrating screen separators widely used in the wood industry. Principle of operation, special applications are described.

What's New in *Technical Publications*

Some 25 new or revised reports have been released by the U. S. Forest Products Laboratory, including four that give up-to-date lists of publications available in several fields of research. Single copies are free upon request from the U. S. F. P. L., Madison 5, Wis.

Report No. 454, deals with wood finishing; No. 444, pulp and paper; No. 704, wood preservation; No. 200, mechanical properties and structural uses of wood and wood products.

Report No. 2145, "Dimensional Stabilization Seminar," summarizes the findings of the January meeting of 80 scientists and industrial men who met at the Lab to consider better ways of stabilizing wood.

Two of the new publications are about pulping various species of wood. Report No. 2142 is "Cold Soda Pulping of Southern Oaks, Sweetgum, and Cottonwood." No. 2141 is "Boards and Papers from Shortleaf Pine, Black Tupelo, and Southern White Oak Neutral Sulfite Semichemical Pulps." The 1959 progress report on "Comparison of Wood Preservatives in Mississippi Post Study" is given in this latest issue of Report No. 1757.

Revised Technical Note No. 236 presents data on nail-withdrawal resistance of American woods; Report No. 1740 discusses the application and use in houses of thermal insulation made of wood-base materials; and No. 2131 gives results of research on water-vapor permeability of matched barrier materials as yielded by two methods of test.

No. 1259 brings up to date the Laboratory's information on the two-coat system of house painting, and No. 2137 analyzes results of experiments with light frame wall construction for houses.

No. 2132, "Hardwood Pallet Manufacturing," combines technical information on pallet construction and design with observations of industrial practices in this field. No. 2136, "Theories of the Combustion of Wood and Its Control," reviews existing information and outlines needed research. In addition to these reports, the Laboratory has issued a revision of its Report No. 513, "List of Publications on Glue, Glued Products, and Veneer;" "Wood Quality in Mississippi's Pine Resources," No. 2143; a revision of "Stresses in Wood During Drying," No. 1652; "Pulping of Mesquite, Manzanita, and Snowbrush," No. 2138; and "Detection and Relief of Casehardening and Final Moisture Content Tests in Kiln-Dried Lumber," Note 213.

JOURNAL BACK ISSUES URGENTLY NEEDED

In order to fill-in several back annual volumes of the FOREST PRODUCTS JOURNAL for libraries and organizations requiring a full library of FPRS information, we need, and are willing to pay the following prices for specific individual copies:

V. II, No. 1 (April, 1952)	**$2.00**
V. II, No. 2 (June, 1952)	**2.00**
V. II, No. 3 (Sept., 1952)	**2.00**
V. IV, No. 1 (Jan., 1956)	**2.00**
V. VII, No. 10 (Oct., 1957)	**4.00**

NOTE: Condition not important so long as pages are intact. Please mail to FPRS, 417 Walnut, Madison.

(advertisements)

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Three Models. Complete Range of Sizes. Lowest-cost installation. Prefabricated, one-piece panels. Exclusive triple-draft. Sizing engineers available to you.

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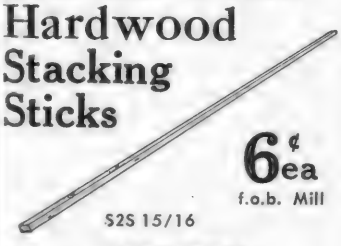
One Car 6-foot Hardwood Stacking Sticks



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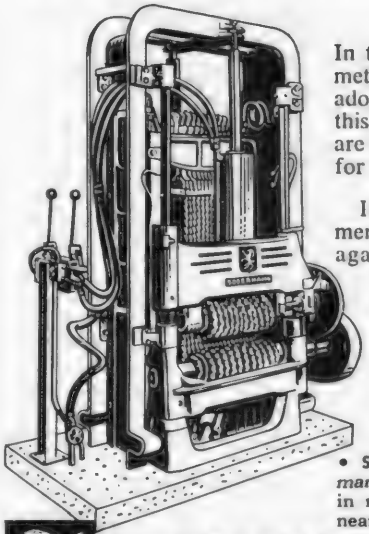
S2S 15/16

GAIENNIE Wholesale Lumber Co.

BOX 1774, SHREVEPORT, LA.

A *modern* mill

is a Soderhamn-Equipped mill



In today's highly-competitive market, all methods of cutting production costs must be adopted if profits are to be maintained. In this situation, worn-out, obsolete machines are costly — down-time and repairs soon pay for new equipment that you never get.

Investing today in new Soderhamn equipment is investing in future profits—insurance against business loss or actual failure. Soderhamn-equipped mills of today are the industry's leaders of tomorrow.

Call, write or wire to have your nearby Soderhamn man show you how to modernize your mill for higher production at lower cost.

• **SODERHAMN GANG SAWS,** *the fastest on the market,* are setting new profit-making records in mills all over the nation. Ask for name of nearest installation.

SODERHAMN MACHINE MANUFACTURING COMPANY

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EMPLOYMENT Opportunities

FPRS Employment Service is operated without charge to members. Organizations having positions to be filled; or persons seeking employment may insert a free listing in two consecutive issues. Inquiries concerning listings, or information should be addressed to: FPRS Employment Service, 417 N. Walnut St., Madison 5, Wis. All correspondence is kept strictly confidential.

Positions Offered

E–339—Two product development engineers. Aggressive men, 25–45, with knowledge of window frames, hardware, sash to develop new ideas. Some knowledge plastics. Design background essential. Exp. in millwork beneficial. Salary in line with exp. (Apr.)

E–341—Director of urea adhesives lab. Senior chemist in charge of resin and hardener formulation, product development, customer application and plant control. In East. (Apr.)

E–342—Adhesives technical service rep. Opportunity for man with experience in plywood and particle board applications. East. (Apr.)

E–343—San Francisco lumber and wood products wholesaler seeks forest products grad. interested in sales career. (Apr.)

E–344—Wood techn. for lab. work on plywood gluing problems. Knowledge of plywood, glues gluing practice required. Work under supervision but be able to carry-out projects and write reports. Pac. Northwest. (Apr.)

E–346—Midwest adhesives co. seeks wood techn. or allied exp. for laboratory technical work. Can lead to tech. representative. (Apr.)

E–347—Operations Mgr. for midwest furniture plant. Wood tech. plus several years supervisory exp. Responsible for all operations except sales, finance, design. Ideal living conditions; expansion possibilities. (May)

E–350—Log and timber buyer, Ohio. National, multi-mill concern. Age under 45 with woods and mill know-how. Advancement possibilities. (May)

E–351—Ass't. Supt. for Hamilton Mfg. Co., Two Rivers, Wis. Young man with furn. exp. in highly mechanized plant. Will supervise 200 employes in plywood layup, assembly, finishing of lab. and school furn. New plant under construction. Age, under 40. Write Personnel Mgr. (May)

WANTED MANAGER

Wood technologist with practical experience in production to manage modern wood working plant in East Tennessee. Applicant must have had several years practical experience in the direction of production and he must be able to assume responsibility so as to take complete charge of the operation. Because plant is highly mechanized, the ability to see that equipment is properly maintained is important. Salary and bonus in high four figure bracket. This is a good opportunity for a competent person.

Send replies to:

E-340, Employment Service
FOREST PRODUCTS RESEARCH SOCIETY
417 North Walnut Street
Madison 5, Wisconsin

Employment Wanted

No. 318—West coast wood technologist, age 43, married, seeks challenging opportunity. B.S. forest products, U. Washington; 6 years leading research lab. as seasoning researcher; plywood experience. (Apr.)

482—Plastics Eng. with wood eng. degree desires position in development work. 5 yrs. exp. in laminates, resin develop., paper impreg. and controls. Currently employed. (May)

519—June grad. MF in wood utilization desires teaching, research, or production management. Presently on staff of Eastern university. Age 25, married.

541—U. Mich. grad with 3 yrs. sales and promotion exp. desires position in plywood or allied fields in Detroit area. (May)

542—U. Minn. grad, Aug. '59, desires production, prod. dev., tech. sales, qual. control in midwest. B.S. in building products mchds. (May)

No. 536—Yale school Forestry, about to graduate. Desires management or research position in composition board, plywood or laminating industry. Age 26; married. (Apr.)

No. 537—Wood preservation engineer. Exp. in research and product development. M.S. wood techn. 1957 (Apr.)

No. 539—May graduate, B.S. forest products, Iowa State. Desires position in product development or quality control. Age 27. Prefer midwest or west. (Apr.)

No. 540—June grad with B.A. in Economics, MS in Wood Techn., U. of Michigan, seeks position in furniture production. (Apr.)

543—Post-grad forester from India with 15 yrs. exp. in conifers, working for MSC at Toronto U. avail. August. (May)

545—Grad. engr. 12 yrs. in production and sales of furn., cabinets, woodwork and plastic laminates desires product promotion and sales-service in woodworking or building. Extensive practical and education exp. S. W. or N. E. (May)

548—Grad. wood tech., 1957, seeks production trainee work in plywood, woodwork, etc. Has been in packaging industry. Midwest. (May)

549—Wood Tech., M.S., wants production or tech. sales and service. Exp. in production, qual. control, development, glues; also statistics, business and forestry. Midwest. (May)

It Will Pay You To CHECK These Facts! Here's What

WILLIAM'S "NO-NIFE" HOGS

Can Do For You:

1. Increase The Heating Value Of Your Wood Scrap!

When reduced to chip form by hogging, wood burns more evenly—gets *all* the heat value possible. Unhogged slabs, trimmings, large pieces, restrict air flow, smother fire, result in inefficient combustion.

2. Improve Quality Of Wood Flour And Sawdust!

Processing wood scrap with a Williams Hog, for resale in the form of wood flour or sawdust, assures more uniform grinding and sizing—much lower labor costs—reduced power requirements.

3. Reduce Handling Cost As Much As 75%!

One man firing wood in chips can handle the same tonnage as would require three men if fuel scrap remained in awkward lengths and pieces that necessitate individual handling.

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Williams has made many automatic installations to hog and convey waste wood to stoker or boiler at tremendous savings in handling expense. Other installations to automatically grind, separate and package wood flour and sawdust result in phenomenal reductions in cost.

Williams equipment will actually pay for itself in a few months, then continue to produce extra profits for many years. Investigate now!

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WILLIAMS

CRUSHERS GRINDERS SHREDDERS

OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

Fig. 1.—Corn (6 weeks old) in a soil-improvement experiment with bark-fiber soil conditioner. Plot 1: Native soil plus redwood conditioner, 8 tons per acre. Plot 2: Same as No. 1, but fir conditioner. Plot 3: Native soil, no treatment. Plot 4: Inert soil plus redwood conditioner, 8 tons per acre. Plot 5: Inert soil, no treatment.

MAKING FERTILIZER—SOIL CONDITIONER FROM

Bark as a Trickling-Filter Media[1]

R. Ed. Burton
Ed Burton Co., Willits, California

Filtering the effluent from canneries and sewage disposal plants through redwood bark improves the bark as a soil conditioner and makes the effluent less harmful to aquatic life in streams that receive it.

REDWOOD BARK HAS BEEN OFFERED is a soil conditioner for some time. The durable nature of the fiber and its low cost recommend it for this use. Its acidity (pH 3.5) and its nitrogen deficiency are its principal limitations.

The acidity is due to a number of organic acids, which are characterized by a buffer action. This means that, if they are neutralized by a basic substance, later more hydrogen ion is generated to bring the pH back down again.

Thus the bark acids can be neutralized only by exposure over a long period of time to a weak base. It was discovered that the effluent from most municipal sewage plant sedimentation tank is slightly basic (pH 7.9). Obviously, this would provide the means of neutralizing bark.

Bark has a nitrogen deficiency because, when it is put into the ground to act as a soil conditioner, certain non-durable portions of the bark fiber and parenchymous tissue begin to decay. The micro-organisms that accomplish this decay need nitrogen for their metabolic processes and growth. This nitrogen can be supplied from the nitrogen in the soil or from nitrogen mixed in or added to the soil conditioners, since bark itself contains virtually no nitrogen. If the nitrogen is taken from the soil, obviously it is not available for plant growth; hence, the soil conditioner is said to have a nitrogen deficiency. The measure of this deficiency is known as the carbon-nitrogen ratio, which can be determined in the laboratory by relating the cellulostic material to the available nitrogen.

In measuring the carbon-nitrogen ratio in redwood bark, the so-called ash method does not give a true picture, since it does not take into account the considerable portion of the bark that is not subject to immediate decay, and hence has little effect on the nitrogen deficiency.

Bark for soil conditioner needs a supply of nitrogen over a long period of time to enable the decayable portions of the bark to rot in the presence of nitrogen and a moisture content between 30 and 60 per cent.

In the search for a weak basic solution containing nitrogen that would also be inexpensive, the field of sewage disposal was investigated.

Virtually all methods of sewage disposal work on the same basic principles. The suspended solids are removed by sedimentation and processed in various types of digesters to form

[1] Presented at the Spring Meeting, FPRS Northern California Section, May 1-2, 1958, Berkeley.

The Authors: Ed Burton holds BS and MS degrees in forestry from the University of California. After 2 years as a company forester, he started his own company, which is involved primarily in debarking and bark utilization.

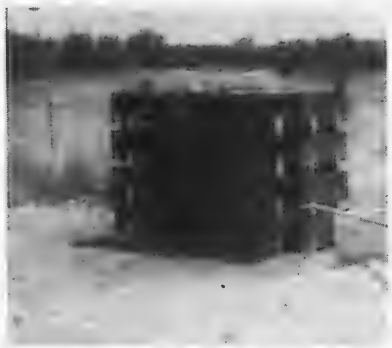


Fig. 2.—Filter boxes filled with shredded redwood bark, for filtering canning-factory effluent.

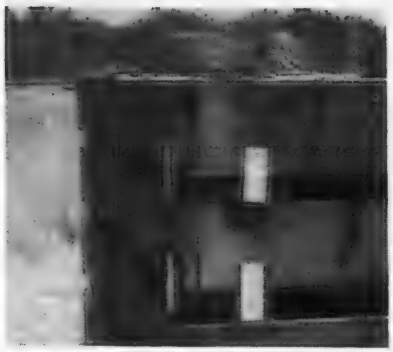


Fig. 3.—Close-up of the filter box, showing effluent distribution over the trickling filter.

sewage sludge. Most attempts at finding saleable products from sewage plants have centered around this sludge. However, a study of the process reveals that most of the valuable forms of nitrogen are soluble and are dissolved in the water that is drawn from the sedimentation tanks. In most sanitary sewage plants, this effluent has in it about 1 per cent dissolved salts and sugars plus varying amounts of chemicals like soap, detergent, and so forth. It also contains more than 70 million coliform bacteria per 100 cc and a pH in the range of 7.5 to 8.8.

When this effluent comes from a properly operating sedimentation tank, it is almost clear and odorless. However, the bacteria that live on the dissolved organic nutrients require oxygen for their metabolism, which they take from the oxygen dissolved in the water. It is this demand for oxygen which creates what is known as the biochemical oxygen demand (BOD). The measure of the BOD in parts per million gives an indication of the amount of dissolved nutrient in the water. The dissolved nutrients are removed by allowing bacteria algae and protozoa to grow in the presence of food, water and air (oxygen) until all or most of the dissolved nutrients are used up. During this process, almost all of the harmful bacteria die of exposure or competition, and can be further controlled through chlorination. If air is not present during this process, then anerobic bacteria take over and produce sulphide salts as well as the gases carbon bisulphide (CS_2) and hydrogen disulphide (H_2S), which gives the effluent a black color and noxious odor. The absence of dissolved oxygen is extremely detrimental to fish and wild life, and forms the main basis for the problem of stream and bay pollution.

Most conventional trickling filter systems for BOD removal involve sprinkling the water to be treated over smooth rocks, sand slag, coal, or other material. This provides a surface for the algae, fungus or bacteria (slime) to grow on and keeps this slime supplied with food and water. As the process continues, the layer of slime becomes thicker, the inner layers die, and the slime sloughs off the rocks. Most systems then provide some sort of secondary clarifier which removes the slime from the water. If the slime does not slough off, the trickling filter becomes clogged, with the result that water and air can no longer reach the slime. The slime then dies and begins to decay. This in turn causes the bacteria count to go up and odors to be produced.

In the process described here, redwood or other bark is placed in a trickling filter instead of smooth rocks, where the slime grows quite readily on the bark. Since the bark is broken down into finer particles, it provides more growing surface for the slime. As the slime grows, very little of it can slough off from the rough surface of the bark. This slime, which is made up of the bodies of countless bacteria, algae and fungi, has a nitrogen content of about 8 to 10 per cent. After about two to three months in a trickling filter, the slime has built up to the point where the bark medium is no longer permeable and "ponding" results. At this point, the bark is removed and placed in piles for about two weeks or more. This allows the slime to decay and be absorbed by the bark fiber. The result is a dark gray fibrous soil conditioner, largely free of bark dust. The pH of 3.5 has been neutralized to 5.0 to 5.8. The nitrogen deficiency has been converted to nitrogen content of 0.49 to 67 per cent as shown in the analysis.

	Redwood bark soil conditioner	Douglas-fir bark soil conditioner
Available nitrogen		
parts per million	6,700	4,900
per cent	.67	.49
Phosphorus (P_2O_5)		
parts per million	1,000	200
per cent	.1	less than .1
Potash (K_2O)		
parts per million	660	540
per cent	.066	.054
pH	5.0	5.8

From the foregoing, it should be evident that the bark should not only provide a low-cost, light-weight medium for trickling filters, but also in the process be converted into a highly saleable end product.

On the basis of the foregoing thought, a pilot-plant operation was undertaken at the sewage disposal plant of the city of Willits. This plant consisted of a foundation of redwood upon which were placed six redwood pentahedran shaped boxes which formed a octahedran shaped unit roughly ten feet in diameter and five feet high. Above these boxes, a distributing arm was provided, which was powered by water pressure. The effluent is pumped from the oxidation pond, not far from where the effluent from the sedimentation tank enters the pond. From the distributing arm, the effluent trickles down over the bark where the dissolved nutrients are used up by the slime, and the bacteria either die of exposure or starvation. The bottom of the boxes have one-inch cracks to allow the water to trickle out as well as to allow air to circulate in the bark medium. Below the box, a small pond is provided to retain the water for about one half hour. This allows the slime that has sloughed off the bark to settle to the bottom in much the same manner as conventional secondary clarifiers. The supernatant liquid is drawn off with an overflow weir, and the water is then ready for discharge into a stream or chlorinator.

The pilot plant was put into operation on January 16, 1957, filled with preparations of fir and redwood bark. To be effective as a trickling filter media, bark must be prepared to give the maximum surface area while retaining good air and water circulation.

Tests showed that redwood bark shredded to resemble coarse hay was most effective as a filter media. It allowed good air and water circulation even after slime had formed. The disadvantage of this shredded redwood bark is that it is very difficult to handle in bulk form. Redwood bark that was run through a wood chipper was found to be almost as effective as a filter media and much easier to handle in bulk form.

Hogged fir bark with particle size $\frac{1}{8}$ to $\frac{3}{8}$ inch in diameter also performed well as a filter media and produced a very acceptable soil conditioner.

Fig. 1 shows the approximate BOD reduction curve over a period of two and one half months. You will note that the BOD reduction increases to the neighboring of 70 per cent within two weeks, where it remains for almost a month. After that, there is a gradual decline in BOD reduction

Fig. 4.—The redwood trickling-filter pilot plant at the oxidation pond of the Willits sewage disposal plant.

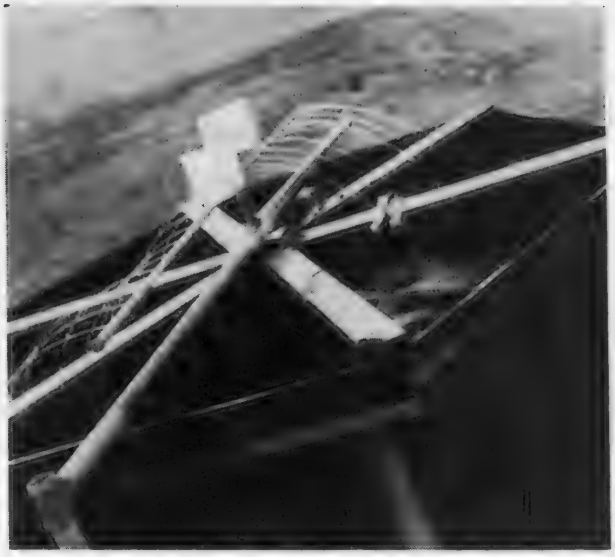


Fig. 5.—The effluent from the disposal plant trickles through the bark. The decomposed bark product that results is marketed as "Sempergrow".

the slime formation reduces air and water circulation.

In addition to the BOD reduction, tests showed that the coloform bacteria count in the water was reduced from more than 70,000,000 per 100 cc to 230,000 per 100 cc.

The pH of the effluent passing through the trickling filter varies from 7.5 to 8.8, but is most commonly around 8.0. There is no significant change in the pH of the effluent as it passes through the trickling filter.

A comparison of this bark filter system of BOD removal with ranges given in "Principles of Sewage Treatment" shows the following results:

	Low-rate filters	High-rate filters	Redwood bark filters
Gallons per sq. ft. per day	46–92	344–688	191
Million gallons per acre per day	2–4	15–30	8.3
Million gallons per acre feet per day	0.3–0.6	2.5–4.0	1.7
BOD in pounds per acre ft.	200–400	1800–3000	1500–3800
BOD in pounds per cu. yd.	0.1–0.2	1.2–3.4	.82–2.45

Low-rate filters consist of sand layers with provision for bark washing at intervals. They are designed to treat the water in one pass.

High-rate filters are now more common. They are designed to allow for secondary clarification and recirculation of the water to be treated about 3 to 5 times.

This bark system should be intermediate with regard to flow, but the BOD removal ranks with the high-rate filter. Since large secondary clarifiers or a large volume of recirculation is not necessary, operating cost would be lower for pumping, and so forth.

The next phase of the program was to evaluate the effectiveness of the product, which is called Sempergrow.

With the rise of intensive cultivation accompanied by the increased use of manufactured fertilizers, there has also arisen the problem of soil conditioning. There is some controversy about the value of organic material as a soil conditioner, but most authorities agree a stable humus increases water retention, improves tilth, and reduces erosion of the soils.

In addition to the chemical analysis, it is necessary to test the value of the product under actual growing conditions. Two principal facts were to be determined. First, what would be the increase in growth and yield that would result from the application of Sempergrow? Second, what possible toxic qualities would become evident.

Five plots four feet by four feet, with a depth of one foot were constructed on a concrete slab. These were filled as follows:

Plot 1: Garden soil plus redwood Sempergrow applied at the rate of eight tons to the acre.

Plot 2: Garden soil plus fir Sempergrow applied at the rate of eight tons to the acre.

Plot 3: Garden soil with nothing added.

Plot 4: Santa Margarita white sand, which is a nearly inert sand found in the Santa Cruz mountains, plus redwood Sempergrow applied at the rate of eight tons to the acre.

Plot 5: Santa Margarita white sand with nothing added.

These plots were planted May 4, 1957. On June 22, 1957, results were tabulated as shown in Table 1.

On August 20, 1957, the corn plants had reached maturity and the results are shown in Table 2.

These results are subject to some error because of the difficulty in measuring plant height. It is possible to state without hesitation, however, that the bark has had a very marked effect on the growth of the plants. Several of the longer range benefits are not shown here, such as the durable nature of the redwood fiber, which means that the soil conditioning benefits will be realized over three to five years.

At present, the bark soil conditioner

Table 1

Plot	Description	Av. ht. Inches	Wt. of thinnings Pounds
1	Redwood plus soil	28	2.5
2	Fir plus soil	22	1.6
3	Soil alone	20	1.25
4	Sand plus redwood	18	1.51
5	Sand alone	12	.25

Table 2

	Height of plants, inches				
Plot	1	2	3	4	5
	72	84	65	50	36
	82	72	74	56	31
	88	60	81	57	30
	76	60	27	46	26
	76	72	76	34	24
	74	82	Dead	70	29
Average	78	71	64.6	52	29
	Immature ears of corn				
	6 ears	4 ears	4 ears	2 ears	0

is being evaluated for such uses as in horticulture and floriculture. The results are promising but incomplete as yet.

One of the most promising ideas turned up for the use of Douglas-fir soil conditioner is as a mulch in the vertical mulching program. This process, pioneered by Purdue University, fills the trench opened by a subsoiler tooth with chopped stubble, corn stalks, rice hulls, sawdust, or shavings. this material keeps the trench open, thereby allowing water to filter down into the subsoil. Experiments carried on at Davis and Purdue indicate increased production and better drainage in vertically mulched plots. When any of the above materials are used in vertical mulching, a nitrogren deficiency develops in the region of the trench. If Sempergrow is used, the roots will tend to concentrate in the region of the trench. This is a most promising field for the woods industry in general when one considers that up to 10,000 cubic feet per acre can be used in one application.

The fields of sewage treatment and soil conditioning are both in need of new tools to meet the challenge of increasing use of clear water and arable land by an increasing population. This same population adds to the stream polution while demanding cleaner water for recreation and wild life. It is hoped that this effort will provide some help to them, and in doing so provide a market for the tons of bark that are burned at our mills every day.

COMMERCIAL USES FOR Redwood Bark Dust[1]

R. W. MILLER
Market Research and Development,
Pacific Lumber Co.,
San Francisco, California

Sulfonated and caustic extracts of the valuable dust fraction are gaining wide use in ore flotation, drilling muds, water treatment, and other dispersing, emulsifying, and reacting roles.

Mud service engineer tests oil-well drilling fluid treated with Palcotan, a sulfonated extract of redwood bark.

THE DEBARKING OF LOGS is economically feasible in many lumbering operations, and is becoming more significant every day. Debarking may increase the yield of lumber from a log by 20 per cent. Saw life is increased, and the bark-free slabs can be utilized in many ways such as in the production of chemical pulps, particle boards, hardboards, and the like.

But the same operation that gives the bark-free wood also gives relatively wood-free bark. Moreover, the bark is made available at a central location from which it can be taken as a raw material for further processing into useful end products. The utilization of bark deserves more attention because of this development.

Other papers in this issue of the JOURNAL cover some specific uses for bark such as in soil conditioning, plant growing media, trickle filters, and hardboards. One paper summarizes the status of bark utilization as a source of chemical raw materials. This paper will attempt to summarize other bark uses that have been developed to date, some of which are beyond the pilot-plant stage and well into commercial produ tion.

Barks are variable in chemical com position and anatomy, and the meti ods of processing them must necessari be tailored to the specific raw materi at hand. The end product desired mu also be considered. Thus, a bark su as that from Douglas-fir or pondero pine might be reduced by grindin whereas a fibrous bark such as th from redwood or cedar might bett be hammermilled to retain its inhere fibrous structure.

In any reduction operation, mecha ical and air classifications can be em ployed to effect a fractionation, at lea partially, into rough classes. Dougla fir, for example, can be fractionate

[1] Presented at the Spring Meeting of the Northern California Section, FPRS, May 1–2, 1958, Berkeley, Cal.

The Author: Robert Miller holds a BS in chemical engineering from Penn. State, and an MS from The Institute of Paper Chemistry. After 4 years in service, he was employed by Simpson Logging Co. and Masonite before joining Pacific Lumber.

Redwood bark fiber insulates the walls of this cold-storage locker. Felting characteristics make the unsupported height possible.

by grinding and screen sizing into cork, powder, and a short, spindle-shaped fiber fraction. Redwood can be screened and air-classified after hammermill reduction to give both long and short fiber fractions and a very fine dust.

Oldest Use: Insulation

Besides giving more or less distinct fractions, the sizing operations may effectively concentrate certain chemical features of the bark. Thus, the cork fraction of Douglas-fir is most rich in tannin-like materials. In the case of redwood bark, the dust fraction has the highest yield of extractives.

One of the oldest uses for redwood bark fiber has been as a loose-fill insulation. The bark fiber supplied for this purpose represents a shredded product of fairly long fiber bundles. Applied at a density of approximately 5 pounds or less per cubic foot, very little settling results, even over long periods of itme and under fairly severe vibrating conditions.

Its usefulness as an insulator is due to its inherent permanence and durability, its high factor of resilience, and its low thermal conductivity. These properties have gained for redwood bark a wide acceptance as a cold-storage and frozen-food insulation material, as a house insulation, and for similar operations.

The redwood bark fiber insulation alone is unusually fire-resistant for a cellulose fiber, but, for certain use, it is desirable to provide a greater degree of flame resistance than is inherent in the material by virtue of its unique composition. As a result, a process has been developed by The Pacific Lumber Company which is termed "Saferzing."

The coarse fraction of redwood bark and a finer amorphous fraction are used very successfully as soil conditioners and as growing media for orchids. They function to increase the moisture-holding capacities of the soil and to permit better aeration. Also, the longer inherent life of the redwood bark material in the soil necessitates less frequent re-potting of plants.

Another use for the coarse redwood bark fiber is as an additive to oil-well drilling muds to seal off areas of circulation loss in the strata. The felting and bridging qualities of the fiber along with its resilience and stability make it ideal for this purpose.

Refined Grades for Felting Operations

More refined grades of redwood bark fiber are suitable for dry or wet felting operations. These fibers handle well on equipment such as the Rando-Web. They may be used alone or in blends with other more expensive fibers in the manufacture of impregnated, non-woven fabrics and batts for use as plumper material and resilient backing in vinyl sheeted panels.

The refined fiber grade of redwood bark is also used in the manufacture of automotive air and oil filters. In these uses, it may be blended with cotton linters in a paper-making operation to form sheets or it may be garnetted with cotton for bulk use. In any case, the physical characteristics of the redwood bark fiber together with the resiliency of the blends give good flow factors and excellent filtering performance.

The acid resistance of the redwood bark fiber makes possible other interesting applications. For example, a sheet containing only refined redwood fiber has been developed for use as separators in electrolyte-retaining types of batteries. The fiber behaves as though it were surrounded completely by a continuous film of lignin. The bark fiber sheet retards the shedding of negative plates so that no sediment space need be provided, and it permits the use of larger, higher capacity plates with no increase in over-all cell size. The sheet has also contributed to the non-spill and dry-charge features of the battery. Other uses involving the acid resistance of the redwood bark fiber are in filtering acid waters or solutions in the ore processing and oil-well drilling industries.

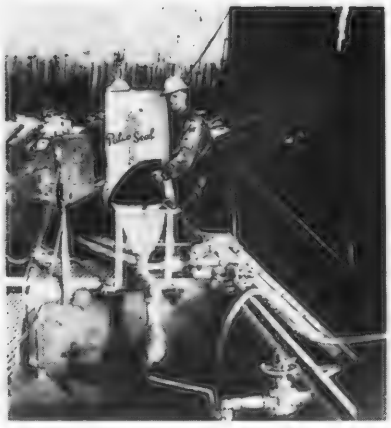
Sulfonated and Caustic Bark Extracts

The ultimate fraction of the whole redwood bark is, perhaps, the bark dust, which is recovered as a fine, amorphous powder. This fraction is the most rich in extractives, and is the raw material for the present Pacific Lumber Co. commercial chemical operation at Scotia, California.

Two redwood bark extracts, Palcotan and Palconate, are already well known in a variety of industries where their dispersing, emulsifying, and reactive characteristics are employed. Palcotan is a sufonated extract of redwood bark, while Palconte is a caustic redwood bark extract.

Palcotan is used to recover fine scheelite from a tactite ore wherein scheelite is floated and garnet, lime minerals, and other gangue materials are depressed. Palcotan is a standard reagent for acting on the minerals in such a circuit. It is added either directly to the No. 1 rougher cell or to the last conditioner as a major point of addition, wtih the cleaner cells receiving additional material as a minor point of addition. Palcotan can be fed as a 2 per cent water solution in quantities totaling from 0.10 to 0.40 pound per ton of dry ore, depending upon the type and quantity of lime minerals present. Palconate has also been used in a modified circuit with comparable results.

The sulfonated extract is being used successfully in the treatment of wet, soft clayey cinnabar ores. It functions as a depressant for altered rhyolite, silicified tuffs, and the like. Cinnabar flotation is advantageous for low-grade, large-tonnage operations and for the flotation of the fine screenings from high-grade opalite-type ores. Both recovery and concentrate grade increases are realized. The Palcotan usage as a dispersant in cinnabar flotation ranges from 0.04 to 0.10 pound per ton of ore. The dispersant is added to the ball mill. A description of the flotation operations on cinnabar at some Nevada and Oregon mills is given in the



Drilling-fluid circulation loss is controlled with bark additive added through a hopper at the drilling site.

September 1957 issue of MINING WORLD.

Both Palcotan and Palconate have given good resutls in the commercial flotation processing of molybdenum and manganese ores.

Another use for Palcotan is in the somewhat limited field of gold amalgamation. The amalgamating of free gold from a sulfide concentrate has always been a problem because of the flouring of the mercury in the presence of the heavy sulfide. Batch amalgamation carried on in a 5 per cent solution of Palcotan and 5 per cent of soda ash will effectively prevent mercury flouring and permit the rapid amalgamation of the gold.

Both the caustic and sulfonated extracts have been used as a replacement for quebracho in the flotation of fluorspar from lime minerals and in the depression of calcite in the flotation of apatite from calcareous gangue. Also, Palcotan has been successful in the removal of contaminating clays in the preparation of glass sands and in the recovery processing of slimes.

Both Palcotan and Palconate are used in water treatment, although Palcotan, the sulfonated extract of redwood bark, has found the most general acceptance. Palconate, the caustic extract, has found some specialized uses for "problem" water.

Palcotan is an excellent direct replacement for quebracho and chestnut tannins in the deflocculation of calcium and magnesium phosphate sludges in boiler waters. It may be used in a blend with phosphate, at about 5 per cent by weight of the phosphate, in boiler water compounds or as a straight organic additive. In the latter case, treatment at about 6 ppm on the make-up water gives fine results. Palcotan has been successful in the treatment of "problem" boilers that do not respond to other treatments.

In cooling water, Palcotan tends to stabilize polyphosphates and to retard their reversion to the orthoform at high pH values. Palcotan can be acidified to low pH values in the range of 2 to 4 to give a passivating action on the metal surfaces of water coolers.

In the petroleum drilling field, Palcotan ,the sulfonated extract, is useful as an additive to the water used in flooding operations. Here it aids penetration into the strata and lowers the hydraulic gradient adjacent to the bottom-hole. Similarly, it is useful in the treatment of waste water for disposal by reinjection.

Small amounts of both extracts (0.1 to 0.25 percent on the dry clay furnish) exhibit strong binding action to give marked increase in both green and dry strength of ceramic bodies. A minimum two-fold increase in the modulus of rupture can be expected for normal usage. Shrinage is reduced. Breakage in handling is minimized.

Palcotan is an excellent deflocculant. It imparts lower water requirements (15–30 per cent water reduction) and easier extrudability to the clay body in the manufacture of bricks and tile. The caustic extract is indicated in some cases, however, particularly where sulfur-free additives are required.

Palcotan is a convenient and economical additive for drilling muds, because it gives close viscosity control, improved gel strength, and low fluid loss. It is nonhygroscopic and does not cake in storage. Its granular, free-flowing, minimum-dusting character makes it popular for rapid addition, without balling or clumping, to the drilling mud. It is completely soluble in cold water, is effective immediately on contact, and does not foam.

Palcotan is particularly effective for fast, shallow-hole drilling. It works well, ordinarily, in cement drill-outs and is effective in muds with salt contents up to 2.5 to 3.0 per cent. At pH values of 9.5 or less, it gives lower gels, viscosity, and water loss than does quebracho.

Palcotan performs well when used for drilling sand formations and in muds with a high, inert solids content, such as barite. It is a water-loss reducer for gypsum muds, and is quite effective in treating gypsum- or cement-contaminated muds. It works well in combination with quebracho, mangrove bark, or lignite, and gives improved gel strength and lower water loss in oil emulsion muds, which means a saving in lower usage of much more expensive water-loss-reducing agents.

Both extract products have been HULL cell-tested to determine their effectiveness as brighteners in metal-plating baths, and have been found to be particularly effective in brightening deposits from cyanide-cadmium solutions.

The sulfonated extract is used commercially in the wetting and dispersing of carbon blacks for masterbatching with synthetic latices. An excellent, low-viscosity dispersion is produced by the addition of 1.8 to 2.0 per cent of Palcotan by weight on the dry weight of the black. It can also be used in the dispersion of the carbon black and other pigments in the manufacture of inks and paints.

In addition to its dispersing function, there is strong evidence of other beneficial effects from Palcotan, including accelerated cure on the end produc following co-precipitation.

In the electrolytic refining of zinc Palcotan can replace bone or hide glu in controlling the smoothness of th zinc deposit on the cathode in the lo pH system.

Both extracts, through the forma tion of insoluble salts, can function i the recovery of metal from solutio in plating and pickling baths. Palcota forms insoluble salts with aluminum chromium and lead, while the caust extract forms insoluble salts with alu minum, cadmium, calcium, chromium cobalt, copper, iron, lead, nickel, stron tium, and zinc.

The sulfonated red wood bark ex tract is a source of polyphenols and is an economical partial replacemen for phenol in phenolic resin manufacture. The range of replacement is from 15 to 50 per cent of the phenol, with optimum results being obtained at about 25 to 30 per cent phenol replacement in most cases.

Palcotan is an effective grinding aid for dispersing cement, cement raw materials, gypsum, asphalt emulsions, and other inorganic slurries. It is also useful as a cement retarder.

Further, it controls the viscosity of bentonite slurries in the preparation of foundry core mixes and is effective as a binder in the forming of molds.

Both extracts are good stabilizers for asphalt and wax emulsions. They can be utilized in emulsifying the oily water-insoluble liquids used in insecti cide spray formulations and in prepa ing aqueous suspensions of insoluble powders such as sulfur, carbon blac and the like. They may be incorpo rated by dry grinding into pigmen and powders intended for water d persion.

Other Uses, Products

The tanning value of the extrac of the barks from many trees ha been investigated over the yea Among these barks are quebrach mangrove, redwood, tanbark oak, var ous firs, and hemlocks. Some ha proved of commercial value and ha been developed into production. Ge erally, the yields of tannin materia

from common American bark species re below those from other possible ources, and the use of by-product resi- lues may not entirely cancel this dis- dvantage. Further, the introduction of ew tannins to the tanning industry s made difficult by the necessity of iving assurance of large supplies over long period of time, and meeting the ther exacting specifications imposed y the highly sensitive nature of the ides.

Bark appears to be a desirable con- ituent in charcoal prepared from slab ood. Although the higher ash content f bark is undesirable for some indus- ial uses, it is not a disadvantage in harcoal for recreational use. Bark lone gives a charcoal that is too fri- ble to make lump charcoal, but this is not too serious if the material is processed to briquettes. The conversion to charcoal of disintegrated bark such as that produced from present de-bark- ing operations would require the de- velopment of special processing equip- ment.

The Weyerhaeuser Timber Co. has produced several fractions of Douglas- fir bark by mechanical reduction and sizing. One product, Silvatan, repre- sented a fraction in which the tannin component of the bark became con- centrated by the process of classifica- tion employed. This material has been used as an additive to oil-well drilling muds.

Other Douglas-fir bark fractions have been prepared under the trade name of Silvacon. The Silvacons rep- resent controlled mechanical fractiona- tion products that have been tailored to a variety of industrial uses such as in vinyl products, magnesite flooring, insecticides, plywood adhesives, and molding compounds. Many other uses are indicated.

An extract of western hemlock bark known by the trade name of Rayflo is prepared by Rayonier, Inc. This ma- terial is in commercial production and finds use as an oil-well drilling-mud additive.

Where To From Here?

The foregoing is not intended to be a complete summary of bark utili- zation. Certainly there are other con- ceivable uses, both chemical and physi- cal, for the barks covered in this and the other papers in this group, as well as for those barks not mentioned. A rather thorough literature survey was compiled by Marian and Wissing titled "The Utilization of Bark." This is an index to bark literature from about 1937 to 1955.

The reduction and utilization of the wood and bark residuals from forest and log-milling operations have long been the aims of far-sighted men in these industries. Reduction of waste is more immediately important, perhaps, since values lost may never, if at all, be completely recovered. It is evident, however, that by his very nature man will usually create waste, and that the processing of wood from tree to manu- factured product inherently produces residues in each reduction step. There- fore, whether we like it or not, we may have more or less waste, but we will have waste. That is, we will have waste in the sense that a pile of saw- dust or bark chunks, for example, of- fers little in terms of effectiveness as lumber. But the collective residue of sawdust or bark need not be looked upon as a necessary evil to be dis- posed of as expeditiously as possible. In these residues, instead of waste, may be found values in excess of the current assessed value of the whole.

A thoughtful realistic approach to this problem must be considered by every organization that deals with the conversion of timber to lumber. The task is not an easy one. Industry is flooded with various materials every day, offered for the correction of many problems, whether they be in mining, plastics, petroleum production, or a host of other industries. Bark is just one of the many materials offered. Therefore, in order for it to be accept- able, bark has to offer the potential customer something attractive quality- wise or price-wise, and preferably both.

To embark on a by-products pro- gram calls for a far-sighted manage- ment to cope with all the sacrifices, some of them financial, that must be made to pioneer new products such as these. But it is a job that must be done, and today, at least, it must be accom- plished by those who create the bark residues.

Chemicals from Bark[1]

E. Farber
Consultant, Timber Engineering Co., Washington, D.C.

In a look to the future, rather than a review of the past, bark is seen as a challenge, not a problem. The keys to the store of bark chemicals include: extraction, mixing, and chemical reactions.

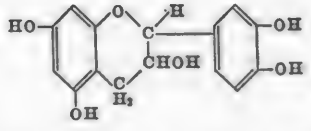
The Author: Eduard Farber holds a PhD in chemistry from the University of Leipzig, after research in Germany, he came to the U.S., and formed his own laboratory. He joined TECO, and became Chief Chemist before he retired to his present status.

When one looks at bark as a reservoir of chemical compounds, he can approach the chemicals to be made from the viewpoint of operations and of end-uses. The operational approach is that of the chemist and engineer, the teleological approach to end-uses is more commonly called market research.

The operational approach can include: 1) extracting, 2) mixing, and 3) chemically reacting.

Extracting with Solvents

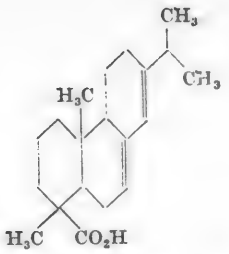
Extracting with solvents can be limited to merely taking out of the bark what is present there, or it can involve chemical change and thus glide over into the third category. The oldest example here is the extraction of tanning materials by hot water. This remains an interesting field. It requires attention to the handling and storing of the bark so as to prevent losses through oxidation and microbial action before the extraction starts.



Catechin, a tanning material; quercetin has the same structure, except that the H_2 in the CH_2 is replaced by O.

The extraction itself is a process that involves more than dissolving the tannins; sugars, dyestuffs, and salts are also disolved. Also, a certain degree of hydrolysis occurs in which the acidic components of the bark open up and hydrate some weak chemical bonds.

[1] Presented at the Spring Meeting, FPRS Northern Calilfornia Section, May 1-2, 1958, Berkeley.



Abietic acid, one of the main constituents of wood rosin.

While such hydrolysis, if allowed to go too far, may reduce some of the tanning values, it is helpful in special instances, as in producing dihydroquercetin from Douglas-fir bark.[2]

A brief review of some recent patents will show the gradual transition from mere extraction to chemical reaction by means of other solvents than pure water:

E. F. Kurth, in U. S. patent No. 2,662,893 (1953, assigned to the State of Oregon) proposes to use "a selective organic solvent for wax, thereby selectively separating the wax from the bark," and then an "aqueous solvent for tannin."

This process has been tested in pilot-plant operations of considerable size. The crude wax, a mixture containing lignoceryl alcohol, lignoceric acid, and ferulic acid was separated by differential solvents into refined wax, black wax, and a soft fraction called balsam. It was estimated that commercial operations could produce about 1.4 pounds of the refined wax, about 1.0 of the black,and 2.4 pounds of the balsam from 100 pounds of Douglas-fir bark. Subsequent extraction with water could then yield about 2 pounds of dihydroquercetin and 3.6 pounds of tannin.

Harry F. Lewis and Marion A. Buchanan, U. S. No. 2,698,233 (1954, assigned to the Pacific Lumber Co.) are specifically concerned with redwood bark, which they cook "in an aqueous alkali sulfite liquor containing at least about 5 per cent sulfite salt based on the weight of the bark, at a temperature of about 90–170°C. until the redwood bark acids are solubilized."

Cooking with sulfite liquors is usually carried out for the production of cellulosic pulp, and the lignin portion of the wood, brought into solution, is still to a large extent a cumbersome waste product; here, however, the process is intended mainly for the production of the dissolved "bark acids."[3]

K. R. Gray and H. L. Crosby, U. S. No. 2,782,241 (1957, assigned to Rayonier, Inc.) is one in the series of patents on alkaline extractions. While the two patents cited previously specify the bark source rather closely, here western hemlock, Douglas-fir, western white fir, spruce, and southern yellow pine are included. They are to be digested "in a water solution of an alkali hydroxide" within a temperature range of "65°C. to 185° C." It is clearly stated that chemical changes occur during such a digestion; water-insoluble materials are converted, "and alkali hydroxide equivalent to from 0.03 to 0.10 part Na_2o per part of dry bark is combined with bark substance." A product obtained by heating western hemlock bark, 100 parts, with 4 parts of sodium hydroxide in 670 parts of water for 20 minutes at 150° C. and thus dissolving 26.5 parts of the bark, contained 12.2 per cent phenolic hydroxyl after spray-drying.

Piotr Zenczak, U. S. 2,781,336 (1957), proposes "reacting the bark with an alcoholic solution of an alkali metal hydroxide—containing at least 5 per cent water." By adding water to the extract, distilling off the alcohol, recovering residues with and without acidification, yields of wax and tannin are obtained.

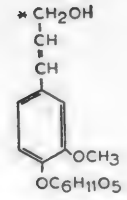
Henry W. Rahn, U. S. 2,783,201 (1957, assigned to Columbia–Southern Chemical Corp.) starts with a material "which contains at least 10 per cent by weight of an acid of the group consisting of tannic acid and humic acid," that is, mangrove bark, which he dries and then mixes with sodium hydroxide "which contains less than 20 per cent by weight of water." The proportions are "from 0.25 to 5 parts of bark per part of sodium hydroxide." The mixture, "when dissolved in water, will form a solution having a pH above 7."

Mixing Bark with Resins or Salts

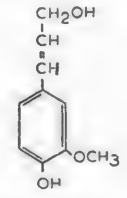
Mixing bark with phenolic resins, or with ammonia and ammonium salts, often involves more than just a mechanical operation. The phenol derivatives in the bark participate in the reactions with formaldehyde when the phenolic resins are used in molding or as adhesives. Some constituents of bark react quite easily with ammonia or ammonium salts, so that part of the nitrogen forms organic bonds.

Little is known about the intimate chemistry of the reactions that occur in these mixtures.

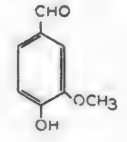
There are few operations with bark that do not lead to chemical changes except the mechanical separation into fiber, cork, and fine dust particles. Nevertheless, it is desirable to consider separately those operations which are designed for the purpose of producing very deep chemical changes.



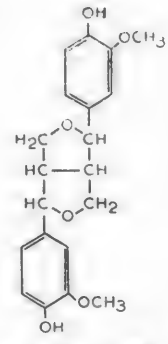
Coniferin, a glucoside.



Coniferyl alcohol, from which "synthetic" lignin has been made.



Vanillin, obtained by oxidation of lignin and the lignin-sulfonic acids in sulfite waste liquor.



Pinoresinol, a product from the condensation of 2 molecules of coniferyl alcohol, part of the structural units in the lignin molecule.

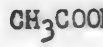
Chemically Reacting the Bark

Eduard Farber in U. S. patent No. 2,744,024 (1956, assigned to the Union Lumber Co.) mixes 10 parts by weight of bark with "about 1 to about 10 parts by weight of alkali metal hydroxide" and heats the mixture "to from about 100 to about 150°C. until the bark particles begin to coalesce." A complete change of the total bark substance is thus produced. Solvents are absent, yet the reaction is rapid. The product is soluble in water and remains so even at a pH below neutrality.

Up to now, the author has not found any other similar chemical reaction for completely reacting all the bark substance. Yet, several such reactions could be foreseen and should have considerable practical interest. Between the

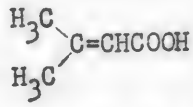
[2] Kurth, E. F. 1953. Ind. Eng. Chem. 45, 2096. Gregory, A. S. et al. 1957. Forest Prod. J. VII (4):135.

[3] Lewis, Harry F. 1949. Utilization of Redwood Bark, FPRS Proc., Vol. 3, 179.

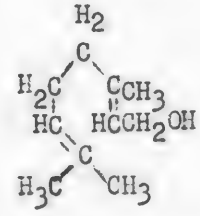


Acetic acid.

Aceto-acetic acid, from 2 molecules of acetic acid.



Dimethyl acrylic acid, from 3 molecules of acetic acid.



Geraniol, an aliphatic terpene, from 2 molecules of dimethyl-acrylic acid.

mechanical separation into differently structured parts, and the extreme chemical conversion into carbon dioxide plus water in the burning of bark, there are gradual, controlled *oxidations* that should result in complex organic acids. Parts of the long carbon chains and aromatic rings should be kept together in such oxidations. Alkaline treatments like those mentioned above would then be only first steps, followed by reactions with oxygen, in any convenient form, perhaps in the presence of catalysts like iron or copper compounds.

The chemical opposite to oxidation is *hydrogenation*. Extensive work has been reported on the reaction of lignin with hydrogen in the presence of catalysts and solvents. The high temperature and pressures used in these experiments should perhaps be avoided in working with bark.

After oxygen and hydrogen, *chlorine* may be pointed out as a reagent that could convert bark into chemical derivatives of interesting properties. Instead of conjectured details about these derivatives, an analogy may help to see the general perspective. Chlorine is used in pulping operations, particularly with straw as the starting material, to convert lignin into a soluble form. The dissolved lignin derivative is a practically unused by-product, about like the lignin derivatives from pulping with sulfite solutions. The Lewis–Buchanan patent cited previously is designed to produce a sulfite liquor that is not a waste, but as useful a product as the fibrous pulp. Chlorination of bark could possibly be developed in the same direction, although the uses for the solubilized and chemically converted part of the bark would be in entirely different fields than those of the sulfite-reacted material.

The reactions with *ammonia* could be pursued and carried much further to the production of pyrrol, pyridine, and quinoline derivatives. This field is wide open to new basic research; practically nothing has been done on it at present.

Still farther away on the horizon are derivatives produced by reaction with *sulfur* for dehydrogenation and sulfurization.

The Teleological Approach

Market research is not quite as new as some pretend; therefore, it may be appropriate to use an old word to introduce a discussion of uses for chemicals from bark. Since large-tonnage consumption is the goal, the fields in which this would be possible must be considered. The six categories, 1) food, 2) shelter, 3) health, 4) transportation, 5) power, and 6) defense, are most obvious.

Food: In times of famine, ground bark has been used in bread; the results have not been reported in detail, but they cannot have been very good. Ammoniation of bark might sometime lead to a product that could be used as stockfeed, about like ammoniated cane sugar molasses. At present, ammonia-treated bark is successfully applied to soils as a carrier and a fertilizer for plants.

The protection of food to prevent oxidation, rancidity, and other deteriorations offer an outlet for chemicals from bark. Flavones and flavanones such as those derived from quercetin are known as anti-oxidants.

Insecticides and fungicides could be prepared by means of the reaction with chlorine indicated above. Chemically modified bark for water purification is another worthwhile subject of exploration. This modification would tend in the opposite direction from the complete solubilization mentioned earlier.

Shelter: Bark enters this field in the form of insulating and building materials.

For the preservation of building materials like wood, canvas, and rope, chemicals derived from bark might find large-scale use.

Health: The most famous of the alkaloid-containing barks are those of the Cinchona species, but there are valuable alkaloids elsewhere; such as in the bark of a plant with the indicative name *Hollarrhena antidysenterica* (R. Tschesche and R. Peterson, 1954. Chem. Ber. 87: 1719). or of *Albizzia anthelmintica* CR Tschesche and D. Forstmenn, 1957, Chem. Ber. 90: 2383).

Complex terpenes and saponins can be extracted from certain barks. Betulin from *Betula alba,* a penta-cyclic triterpene, is related to the saponins such as those from quillaia bark. R. L. Hossfeld and F. H. Kaufert (Forest Prod. J. V. VII (12): 437) have described aspen bark as containing salicin (o-hydroxymethyl-phenyl-beta, d-glucopyranose) and populin (6-benzoyl-salicin). They are present in the alcohol-benzene extractives to the extent of about 16 per cent of the weight of the bark.

Other barks contain glucosides of similar nature. These are potential raw materials for therapeutic and antibiotic substances.

Transportation: Ingredients for road surfacing, active extenders for rubber, and additives in oil processing are three of the main potential applications for bark chemicals. Only the last-named has been actively explored. Several alkali-extractives and the conversion product according to the above-mentioned Farber patent are employed as additives to oil-well drilling muds.

Power: Whole bark or residues from extractions are sources of heat. In many locations, the burning of bark as a heating medium could be greatly improved by judicious predrying and air regulation.

Defense: The aromatic compounds and the carbohydrates (cellulose and hemicellulose) of bark can be nitrated. With careful attention to uniformity of source material and operation, the nitrated bark might be used in rocket fuels.

Conclusions

In an article on "log barking for greater profit," (J. of FPRS, V. 3, p 54, 1953) E. P. Ivory wrote: ". . . the major benefits will only be achieved when research has pointed the way for bark to play a major role in agriculture and industry." In the six years since then, the progress has not been spectacular. Perhaps research has not been extensive enough.

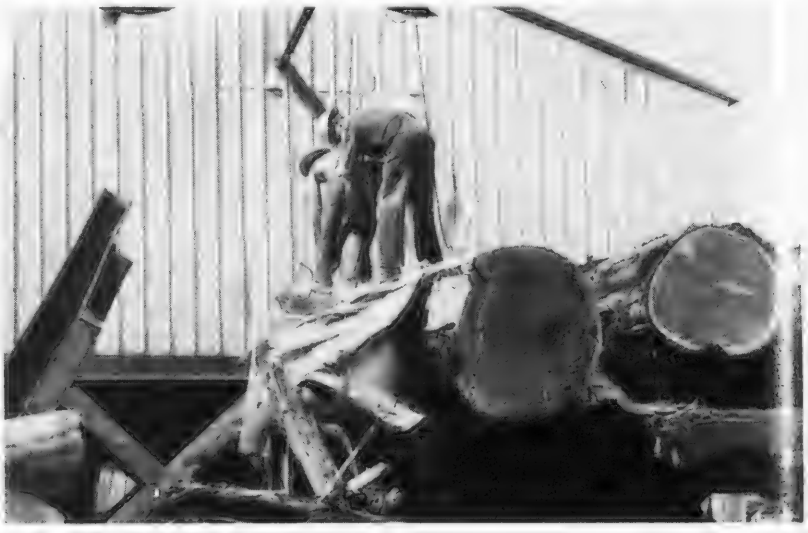
While it is good to take a critical look at this situation, it is still better to study what has been accomplished in research so far, and which further steps can now be made on relatively solid ground of new knowledge. Chemical relationships between the cyanidins of flowers, the flavones and flavonones such as catechol and quercetin, and the guaiacyl-glycerol derivatives in lignin are scientifically intriguing; they can also supply much food for thought about new chemicals from bark.

Utilizing Bark at a Medium-size Mill...

PROCESSING AND MERCHANDISING BARK PRODUCTS[1]

E. P. Ivory and P. Field
Ivory Forest Products Co.,
Dinuba, California

One pound of bark can be recovered for each board foot of western conifers delivered at the mill. Processing techniques are now known, but merchandising processed board products requires intensive market study and development.



SEVERAL ATTEMPTS HAVE BEEN MADE at Ivory Pine to determine the amount of bark available from each 1,000 feet of logs sawn. Measurements were made of the quantity removed from a given volume of logs going into the mill. Given yardages were weighed, and it was found that from 900 to 1,100 pounds were obtained from each thousand feet, but it was obvious that there were numerous variables. For one, not all of the bark was being recovered. Much of it floated into the pond, was knocked off at logs decks, or left on the short logs that could not be debarked.

The bark is removed by rossing, which does not remove all of the bark, but does take some wood from the body of the log and from the knots.

An excellent check was obtained for the year 1957, however. About 22 million feet of all species were sawn, and of this amount approximately 2 million feet was cedar. The cedar bark was not saved, but a skimming method was developed to recover the pine and fir bark from the pond, and pick up that which was knocked off at the log decks. With about the same carry-over at the beginning and end of the year, it was found that 10,200 tons had been shipped. This was, then, the yield from 20,077,000 feet of pine and white fir logs. It figures out to 997 pounds per 1,000 feet. The bark lost more than offset the wood included, and, of course, there was a tremendous volume of bark knocked off in the woods that could not be reclaimed.

It was found that there was considerable variation in yield between species and the size of the logs. Generally, the white firs yield more bark than the pines, and the big old logs yield more than the smaller ones.

On the basis of over four years of experience, a good estimate would be that there is one pound of bark for each board of mixed conifers from the Sierras, or 1,000 pounds per 1,000 board feet of logs delivered at a sawmill, or, projecting further, there is one ton for each 2,000 board feet. This figure might be increased by closer standards of bark saving at all points from the tree through the saw mill.

Bark Preparation Depends on the End Use Intended

The treatment or preparation of bark depends on the uses to which it is to be put. There are two broad categories: raw bark and composted bark. The raw bark seems best fitted to the growing of epiphytic plants, such as orchids. Orchidists are usually scientific in their methods, and use various formulas for feeding. They correct their water, make frequent checks of the pH, and control detrimental fungi. Some other growers can also use raw bark successfully, but generally they prefer composted material.

The first orchid growers were quite content to take the run-of-the-mill bark, and it was little short of phenominal how this use spread through the industry. They now have become selective, largely with respect to the size of the particles. *Cattleya, odontoglosum, cypripedea,* and *laelia* growers prefer granular material of medium size, which is from something smaller than a pea to the size of an eastern chestnut. Growers of *vandas* and *phalaenopsis* prefer a coarser material up to the size of a horse chestnut or an english walnut. Producers of *cymbidiums* are inclined to use a mixture of sand and bark of unsifted grade.

Some object to wood in the bark, others think it is beneficial. The question of size is largely a matter

[1] Presented at the Spring Meeting, FPRS Northern Calilfornia Section, May 1-2, 1958, Berkeley.

The Authors: E. P. Ivory graduated in forestry from Syracuse University. He held a number of positions in industry, lumber associations, and at the FPL before starting his own firm.

Peter Field holds a BS degree from the University of California. He has been with Ivory Forest Products since graduation.

preference, and sometimes of economy. The fines break down too quickly for some, and the coarse breaks down too slowly for others. One more or less has to permit the orchid grower to tell him what he prefers, and be prepared to furnish it.

What is the economy of growing orchids in bark? First, it is their natural medium. Most orchids in nature are in the form of epiphytes growing on the bark of a tree, but not necessarily taking their sustenance from it.

Efforts to use bark for orchid growing were made from time to time over the past 100 years, but there was little success until white fir bark was tried. The principle growing medium used previously was osmunda, the compressed roots of fern. Osmunda, which is fairly expensive, came in compressed bales that had to be broken up. Only an expert was able to pot in it, and at least a year was required for the new plants to establish themselves in it. With bark, almost anyone could pot in it quickly and easily, and the root growth was so rapid that blooms frequently came again within six months. The material even lends itself to automatic repotting, because it flows freely. It is very easy for the amateur to use, and some commercial orchid growers believe that its broad introduction will permit growing in the home without a hot house.

The Market for Raw Bark is Limited

As mentioned earlier, the bark is rossed from the logs by a big cutter head with inserted saw teeth. This pulverizes the bark in sizes from fine dust to walnut-size pieces.

Bark picked out of the pond or from under a log deck is run through a Williams hammer hog, and is reduced to granular shape. Afterwards, the ground bark is subjected to various sifting or grading processes designed to meet the demands of the customer. Since approximately 30 tons of bark is produced on each operating shift, it is obvious that the processing equipment must be of good design and considerable size.

Much of the bark is sold in bulk, and goes from the mill in 20-ton loads to points in California and the nearby states.

For shipment to the East, however, bulk shipment is not acceptable. Burlap sacks proved unsatisfactory because the rapid action of the bacteria in the moist bark often broke down the bags before they reached their destination. Accordingly, it was necessary to develop a multi-walled sack with a polyethylene lining. These sacks cost from 18 to 27 cents each, and require special sacking equipment. Naturally, this ran the cost up to a rather high point.

For the commercial grower, the bark is put up in rather plain 3-cubic-foot sacks. Bark for sale to the hobbyist is put up in 1- and 2-cubic-foot sacks of fancy design. These sales are made through distributors or through the growers themselves. A car-load of such sacks runs from 8 to 10 thousand dollars, and a good price can only be obtained in such quantity.

As to the size of this market, some checking showed that, for the United States, as a whole, it runs between 2 and 3 thousand tons per year. This is less than one third of the production of a small plant. Obviously, this market can be quickly and easily saturated.

Composted Bark Has the Greatest Potential

The big market and the broadest sphere of use is for bark that has been composted. Composting means breaking down the bark fiber into humus. Humus, then, is a reagent that causes soil to give up the chemicals needed for plant growth. It also favorably affects the texture and moisture-holding qualities of the soil, and favors the development of beneficial soil bacteria. This is the principle material designed by growers of nursery stock, by landscapers, and by home gardeners.

How is this composting achieved? Early efforts at Ivory Pine included both bark and sawdust. Fruit and vegetable wastes, with which the area abounds, were added to introduce bacteria. For example, a tomato packing plant will often discard 125 tons in one day. Also, poultry producers have tremendous quantities of viscera, feathers, blood, and so forth, which they are very glad to dispose of. All of these worked well with the bark, but they did very little with the sawdust. Bark composted satisfactorily in 6 months, but sawdust was little modified after 2 years.

It was obvious, then, that bark did not need the introduction of special bacteria or other wastes; that it had within it inherent qualities that would produce a good compost. If the many types of soil bacteria that get into the bark when logs are dragged through the forest, as well as the vast number of fungi, were not enough, then nature would provide them out of the water of the pond or even out of the air.

How Composting is Accomplished

The principle process is one of breaking the bark down into humus, or reducing the carbon-nitrogen ratio. The work is done by bacteria and fungi, but to keep the bacteria active, varying amounts of nitrogenous salts dissolved in water are added. Some of this is introduced after the bark is pulverized, and more is introduced into the composting beds as necessary.

Proper composting requires aeration, which is achieved by stirring up the piles when the need is indicated. These piles are 5 feet deep, 20 feet wide, and 150 feet long. Bacteria cannot stand too high a moisture content, and will also die if it gets too low. The composting ground used at Ivory Pine covers more than an acre. The accumulation of rain water cannot be prevented, but dryness is avoided by sprinkling water from a truck.

The principle index of bacterial activity is the temperature within the piles. An ideal temperature is 139°, although 178° has been recorded in composting garbage. Whenever the bark compost temperature drops below 130°, a pronounced slackening is indicated, and necessary steps are taken to increase bacterial activity. Generally, 6 months is a satisfactory period of time to produce good compost. A year is better, but excellent results have been obtained in 3 months under ideal conditions.

The question is often asked: What degree of composting is achieved? There is no satisfactory test for humus as such, but generally customers seem to prefer to use material when the fines have been broken down. That will leave various sizes of particles, which break down slowly over periods of up to 5 years. This is one of the big advantages of bark compost. There are enough nutrients present at the outset to give life and growth to the plants. In fact, there is enough left over so that, as the larger particles break down slowly, the soil does not suffer from denitrification, but instead seems to achieve a new volume of humus each year.

Why Bark is Composted More Readily Than Sawdust

The opinion here is that bark composts more readily because there is included in the bark the cambial zone of the tree. This is the growing zone of wood very close under a single-cell formation called the cambial layer, plus the much thicker area in the bark that contains the active, nutrient qualities of tree life. Here there are numerous xylem cells carrying moisture and soil minerals up to the leaves where through the process of photosynthesis plant foods are made. These foods return to the root zone in the phloem cells, and it is even possible that some

of them make more than one round trip, increasing in richness with each. This is an area heavy with proteins. In some trees it is 1/2 inch thick on the bark side and at least 1/4 inch thick on the woody side. Older body wood does not contain these active elements, and for that reason it is difficult for bacteria to live in sawdust and reduce it to humus.

Of the various common species cut, the white firs seem to have the heaviest cambial zone, and of the two most available species, *Abies magnifica* seems to be the most easily composted. It is often seen that, when a white fir log has been debarked and left in the water, it will develop a gelatinous layer of clear, viscous material that resembles the white of an egg or vegetable gelatin. This material is smooth and slimy, but does not readily fall away. It seems that it is this material of an albuminous or protein nature that lends itself most rapidly to composting, and gives to plants the rapid boost obtained from this process.

It has been found also that it is important to the composting action that this area of the bark be kept in a naturally moist condition. If dried, its reaction seems to be like that of pasture grasses. When they are green they are full of nitrogen-bearing proteins, which they give to the cattle. If they dry out in the fields, they lose much of this quality. The same is true of alfalfa, which is cut while it is still green and baled before it has a chance to dry out. When fed to cattle, it then is still rich in proteins because the nitrogen has not been allowed to leach out.

Merchandising the Products

The composted bark is sold both in bulk and in sacks. Some customers want the material just as it comes from the sawmills, while others want various fractions from it. People developing a lawn want the finest fraction, whereas others who want longer-lasting material prefer a considerably courser fraction. Here again, the compost is shipped in bulk loads of 20 to 22 tons to points within a radius of 250 miles. The freight in this case is usually about three fifths of the selling price.

The composted bark put into sacks is usually ground to a fairly uniform texture in a verticle hammermill. It is put into 2-cubic-foot sacks for the home gardner, and 1-cubic-foot sacks for the smaller user. Some of it is put into 3-pound packages for sale through mass markets. These smaller amounts are normally used in the planting of a few outside bushes or more frequently for window-ledge gardening. To this there must be added various types of feeding composts that are fitted to the plant to be grown. There is a rose mixture, an African violet mixture, and a general-purpose potting medium, each with its own treatment. Naturally, the smaller the package, the higher the net return FOB mill, but it is also obvious that since 10,000 three-pound sacks contain only 15 tons, the gross market for bark in this form is limited.

To sell this material to the home gardener as well as to the nurserymen who will distribute it, it has been necessary to undertake an extensive advertising program. This program was started over three years ago, and is now beginning to take effect. It includes advertisements in magazines such as Sunset, garden supplements to the big Sunday newspapers, and trade papers. It also includes displays and plans for the distributor. The help of garden specialists, who make it a point to lecture to amateur gardeners, is enlisted, and brochures and samples must be made up for them to distribute.

The major element in sales is word-of-mouth from neighbor to neighbor, but since it takes a season to observe results, that is not especially fast. However, there is evidence that the advertising program is paying off, and that the pacakaged material is moving in continuously larger volumes.

Competition Limits the Price

To process this bark along with some other by-products at this plant, an investment of between 160 and 175 thousand dollars has been made. This does not include the advertising investment. This equipment is not used exclusively for bark but does serve to the extent of approximately one-half. It can only be developed as the need indicates, but at all times the effort is made to reduce the element of labor and make the flow automatic. Bark lends itself quite readily in this respect, and it is little short of remarkable to see a stream of this material pouring like water from a 3- or 4-inch pipe in which the flow is induced by pulsating air pressures up to 7 pounds per cubic inch. There is a seasonality factor in this program, and the equipment must be of sufficient size to take care of the surges.

Bark is far from alone in the field of soil amendments and conditioners, and the price at which it can be sold is dictated largely by some of these competing materials. For example, in the San Joaquin Valley one can buy powdered Gypsum mined in that area, which is from 60 to 70 per cent pure, hauled to his ranch and distributed on the field for from $5 to $6 per ton. The farmer can buy chemically pure Gypsum finely ground in sacks at $12 to $13 per ton delivered to his farm. Inorganic nitrogen fertilizers can be had at from $50 to $60 per ton, and many agricultural supply houses will drill into one's fields, liquid fertilizers like aqueous ammonia at a surprisingly low cost. Then there is steer manure, which again sells for $5 per ton spread, and many cotton gins compost the waste and sell it for very little money. These elements dictate the price that can be obtained for composted bark in bulk quantities as far as the farmers are concerned.

In the nurseries and home gardening stores, there is steer manure in sacks at as low as 50¢ for 2 cubic feet, and rarely selling for more than $1. Bark compost must bring at least $1 per sack at the plant to show any profit, and retail at upwards of $2. Peat moss is the traditional contender for the favor of the home gardener. It comes in from Germany, Canada, and from the United States. It can be bought at any nursery for prices that are surprisingly low. Leaf mold, gathered in the foot hills, is another competitor. Its cost is that of raking, grinding, and sacking. In the 3-pound package field, there are already many products in the market, well advertised and distributed, with which bark compost must compete.

Bulk sales have been the chief outlet, but the sale of packaged material is growing slowly and steadily. It takes a long time to establish a product of this kind in the public mind, and when one undertakes it, he should expect to make a sizeable advertising investment to say nothing of the plant. Geography, too, plays an important part, and if the material has to be hauled long distances, the freight may keep it out of the market.

Conclusion: Bark Utilization is Making Satisfactory Progress

To date, progress in marketing bark products has been good. The use of bark compost will continue to increase, although it sometimes takes 2 to 3 years to convert a volume user from another growing medium he has used for 20 or 30 years.

On the basis of the past few years of experience, one can reasonably expect that bark, when properly prepared, will slowly but surely create a market that will absorb the output of several mills of the size of Ivory Pine. To bring in a return that is commensurate with the effort and investment, however, it will be necessary for those who sell bark products to get together, as have the manufacturers of peat moss, so that they may turn out a uniform product, and create a strong market through advertising.

UTILIZATION IN NORWAY . . .

Bark in Hardboard[1]

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In Norway as in the U. S., bark utilization is a major problem. as described here, small amounts are used in hardboard with good results, and considerably larger amounts can be used without adverse effect. Extractives may cause variations in properties.

—Photo courtesy Blaw–Knox

Unbarked slabs go directly to the chipper in the All-Board process for making hardboard.

THE POSSIBLE UTILIZATION OF BARK in fiber products, such as soft- and hardboard has received very little attention.

It has been estimated that the annual timber cut in the United States would make available about 20,000,000 tons of bark. While minor quantities of some barks, such as Douglas-fir *(Pseudotsuga menziesii)*, redwood *(Sequoia sempervirens)*, western hemlock *(Tsuga heterophylla)*, and white fir *(Abies concolor)* are being utilized, the utilization of bark still remains among the major unsolved problems of the timber-using industries the world over.

The reasons advanced for not using bark in fiberboard compositions appear to be several, some of which are: 1) when bark is incorporated with wood the resulting pulps may have too high freeness values to be suitable for wet-lap board formation, and 2) the presence of bark would weaken the board below acceptable standards.

Still another objection often raised is that bark would produce a product that is too dark in color. These objections did not hold for Douglas-fir bark as indicated by Anderson and Runckel (1).[2] Their investigation revealed that, rather than being detrimental, incorporation of Douglas-fir bark in the hardboard compositions produced a satisfactory product without the addition of the usual sizing agent. The unique sizing action of Douglas-fir bark, which produces a board with good dimensional characteristics, stems from the wax content present in this bark. As the result of this laboratory investigation, a hardboard plant was installed by the Oregon Lumber Co., Dee, Oregon (2).

During 1956–57, an investigation at the Norwegian Pulp and Paper Research Institute was concerned with the influence of some Scandinavian barks on hardboard properties.

The total land area of Norway is about 80 million acres, of which 18.8 million acres (23.5 per cent) is productive forest area. The volume of standing timber is 137 billion bd. ft., of which 80 per cent consists of softwood (spruce and pine) and the remaining 20 per cent hardwood (mainly birch). Approximately two-thirds of the softwood is spruce.

The annual timber cut in Norway is about 5 billion bd. ft., of which 36 per cent is consumed by the pulp, paper, and wallboard industries, 30 per cent by sawmills, 9 per cent for special timber, and 25 per cent as fuel. Spruce is largely used by the pulp and paper mills, pine as saw timber, while birch is largely used as fuel.

The important point from Norway's standpoint is the dominating position forestry plays in the economy of the country. Pulp, paper, and wallboard are the most important export products; they account for 30 per cent of the total export revenue. Lumber is not exported, since the entire output is required for the domestic market.

To keep installed forest products facilities at present levels of production, Norway is required to do some deficit cutting. This is manifest, since Norway is importing about 21 million cu. ft. of pulpwood and 42 million bd. ft. of lumber annually to fulfill raw material requirements. Thus, it becomes apparent that the only way in which this country can expand output of forest products is to look to both mill and logging residues.

The annual timber cut in Norway would yield approximately 31.7 million cu. ft. of bark (3). Most of the

[1] Presented at the Spring Meeting of the Northern California Section, FPRS, May 1–2, 1958, Berkeley, California.

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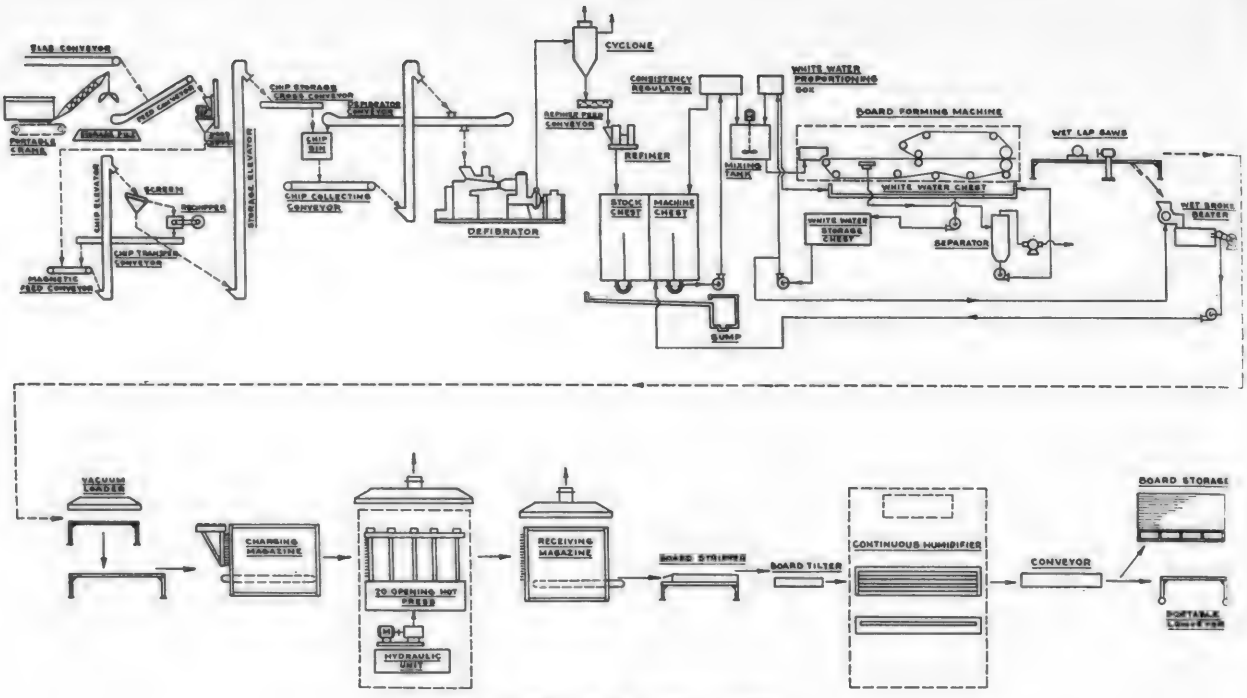
[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.



Flow sheet for the All-Board process.

timber in the Scandinavian countries is usually stripped of bark in the woods; hence this bark forms a considerable portion of the unused logging residues. The debarking of logs in the forest represents about 50 per cent of the felling time; consequently if debarking could be centralized at the mills, considerable savings in harvesting costs would result (4). However, centralized barking would pose the problem of the disposition of the accumulated bark.

In addition to bark in the above form, some of the bark in the Scandinavian countries appears as unbarked slabs and edgings at the sawmills. Such timber is sometimes transported unbarked to the mill site, since the quality is better preserved when the wood is protected by the bark. A recent survey (1953) in Norway indicated that a total of 25 million cu. ft. (piled) of debarked slabs and 13 million cu. ft. (piled) of unbarked slabs were produced at 1,053 sawmills during the year (5). Of the unbarked slabs, about 77 per cent was used as fuel, 11 per cent further processed into fiber products, 6 per cent to other industries, and the remaining 6 per cent went unused.

While most of the bark-containing mill residue is used as fuel, some pine and spruce bark in this form is used in Norway in producing fiberboard (6). Bark-free sawmill residues, however, such as barked slabs, edgings, and small wood, are still the most prevalent raw materials used in producing fiberboard. The amount of bark in the final product, which varies, probably never exceeds 10 to 15 per cent. The fiberboards so produced usually are slightly darker than the bark-free product, otherwise their properties appear to be quite similar to the fiberboards produced from bark-free wood.

Thus, while some bark is employed in the production of fiberboard in Norway, the amount used is but a small fraction of the total bark available. It is apparent that bark utilization in Norway, as elsewhere, is among the major unsolved problems in the timber-using industries.

In attempting to determine possible uses for unused bark residues in the established major Norwegian forest products industries, namely pulp, paper, saw timber, and fiberboard, it appeared that the latter was the only industry that might be in position to use more bark in the manufacture of its products. In order to appraise, in part, the possible uses of greater quantities of bark in fiberboard compositions, some preliminary laboratory hardboard experimental studies were carried out to determine what effect the addition of various quantities of specific barks would have on hardboard properties (7). The three major bark species available in Norway were chosen for this study, namely 1) spruce, *Picea abies;* 2) pine, *Pinus sylvestris;* and 3) birch, *Betula verrucosa.*

Fresh green slabs of each of the three species were secured, and the bark was separated from the wood. The bark and wood were chipped separately, and wood-bark compositions were made up consisting of 100 per cent wood, 75 per cent wood and 25 per cent bark and 50 per cent bark and 50 per cent wood. These compositions were defiberized in a laboratory Asplund defibrator, followed by raffination until desired pulp freeness was obtained.

No difficulty was encountered here in preparing bark wood pulps with the desired freeness, which thus seems to eliminate one of the objections reportedly encountered when bark-wood compositions are used.

The amount of pulp recovered from each composition was determined, and the pulp yields, together with pH values of each pulp immediately after defibration, are reported in Table 1.

As these results indicate, when bark is added to wood chips and then processed into fiberboard pulp, the pulp yield is usually lower than when only bark-free wood is used (6). The final pulp yield will be contingent on type or species and amounts of bark employed. These lower pulp yields with barks stem from the usually high

Table 1.—PULP YIELD

Raw material composition	Pulp yield, per cent	Pul pl
Spruce, 100% wood	86.8	4.
Spruce, 75% wood—25% bark	80.2	4.
Spruce, 50% wood—50% bark	74.8	4.
Pine, 100% wood	85.6	4.
Pine, 75% wood—25% bark	83.6	3.
Pine, 50% wood—50% bark	77.1	3.
Birch, 100% wood	89.5	3.
Birch, 75% wood—25% bark	85.6	3.
Birch, 50% wood—50% bark	81.7	3.

Table 2.—PROPERTIES OF UNSIZED HARDBOARDS

Raw material composition	Pulp pH	Spec. grav.	No heat treatment: Water abs. 24 hours (Per cent)	No heat treatment: Thickness swelling 24 hours (Per cent)	No heat treatment: Modulus of rupture psi	Heat treated[1]: Water abs. 24 hours (Per cent)	Heat treated[1]: Thickness swelling 24 hours (Per cent)	Heat treated[1]: Modulus of rupture psi
Spruce, 100% wood	5.0	0.990	53.0	30.9	7952	27.8	18.0	8676
25% bark—75% wood	4.9	.955	56.2	29.5	6688	46.8	21.7	7583
50% bark—50% wood	4.7	.970	51.6	25.3	4927	46.5	21.2	6035
Pine, 100% wood	5.4	.995	56.8	32.9	7142	26.7	18.5	8207
25% bark—75% wood	4.3	.970	41.1	20.9	4984	25.5	14.5	5694
50% bark—50% wood	4.0	.960	20.1	12.9	4189	16.9	11.0	3834
Birch, 100% wood	4.3	1.000	66.3	41.4	7753	62.3	33.5	7696
25% bark—75% wood	4.3	1.000	53.7	30.0	5169	55.0	27.6	5183
50% bark—50% wood	4.5	.905	62.8	28.3	3564	56.6	25.9	3763

[1]Hardboards heat treated 3 hours at 165°C.

percentage of water-soluble extractives, such as tannins and carbohydrates, present in barks, and also, barks usually contain more amorphous material, some of which passes through the sheet-forming screen.

In the preparation of the hardboards from each composition, three boards were prepared without sizing agents, while the remaining three boards were prepared with size by adding ½ per cent paraffin, based on dry weight of pulp, followed by 1 per cent alum to the pulp slurry prior to sheet formation. The purpose here for including boards made without the sizing agent as normally practiced in making and testing fiberboards, was to overcome any masking effect that sizing might have on some unusual property that might be exhibited by the bark (1).

Sufficient pulp-water mixture was weighed to make a ⅛″ by 12″ by 12″ hardboard, and the wet sheet was formed in the usual manner. The wet lap was then dewatered in a cold press, and the pre-pressed mat was put between a caul plate and screened-covered caul and transferred to the hot press. The mats were pressed at 200° C., for a total pressing cycle of 13 minutes, which included 1 minute going to maximum pressure of 700 psi, held for one minute at 700 psi, released to 210 psi, for 5 minutes, then back to maximum pressure of 700 psi for 6 minutes, and then pressure was released and the board was removed.

In the manufacture of fiberboards in the Scandinavian countries, heat-treating of hardboards after removal from the hot press is an integral step in the preparation of the finished product (8). This step is usually accomplished by subjecting the hardboards to a temperature of 150–180°C. for several hours in a chamber. This treatment is used to import greater strength and lower water absorption (that is, increase dimensional stability) of the hardboard. In the United States, on the other hand, this heat-treatment step is, in almost all cases, omitted for the production of untempered or standard hardboards. When tempered boards are produced in the United States, the oil-heat tempering process is usually employed. Thus, for the American processed standard hardboard to meet low water absorption and dimensional stability requirements, it is necessary to add sufficient amounts of sizing agents, such as rosin, paraffin, or both, together with alum to the fiberboard pulp suspensions, so as to meet specifications.

In most of the fiberboard laboratories in Scandinavia, the results and data are based on hardboards that have been heat treated, while in the United States most results are reported on hardboards that were not heat treated. Therefore, it was of interest here to determine the physical properties of the boards prepared by each of these procedures as practiced in each of these countries. For this purpose, ½ of each board was heat treated at 165°C. for 3 hours, while the remaining half received no heat treatment before testing.

The properties of both unheated and heat-treated hardboards produced with no added sizing agents are reported in Table 2.

In referring to the various boards that were not sized and received no heat treatment, only one composition met specifications of water absorption (that is, maximum of 30 per cent water absorption in 24 hours), and that was the board containing 50 per cent pine bark. All the remaining boards failed to meet this specification. Turning to these same unsized boards, but which received heat-treatment, four of the compositions met water absorption requirements; these were the 50 per cent and 25 per cent pine bark boards, together with the 100 per cent pine and spruce wood boards. None of the boards containing spruce or birch barks met requirements.

It should be noted that the modulus of rupture of the hardboards became lower when bark was added to the composition. In nearly all cases, these values were increased when the boards were heat treated. And, in general, none of the boards containing spruce and pine bark was submarginal in strength values.

The properties of the sized (½ per cent paraffin and 1 per cent alum) hardboards were next determined, and the results are summarized in Table 3.

In referring to the sized boards that received no heat treatment, two compositions were acceptable, namely the 50 per cent and 25 per cent pine bark boards, while the 100 per cent pine wood board was marginal. On the other hand, when the sized boards were also heat treated, all spruce and

Table 3.—PROPERTIES OF SIZED (½% PARAFFIN—1% ALUM) HARDBOARDS

Raw material composition	Pulp pH	Spec. grav.	No heat treatment: Water abs. 24 hours (Per cent)	No heat treatment: Thickness swelling 24 hours (Per cent)	No heat treatment: Modulus of rupture psi	Heat treated[1]: Water abs. 24 hours (Per cent)	Heat treated[1]: Thickness swelling 24 hours (Per cent)	Heat treated[1]: Modulus of rupture psi
Spruce, 100% wood	4.4	1.000	39.2	23.1	7426	17.4	14.6	8619
25% bark—75% wood	4.3	.975	47.6	25.7	5751	22.2	15.8	7668
50% bark—50% wood	4.3	.970	41.2	20.8	5495	27.8	15.0	5935
Pine, 100% wood	4.2	.995	29.1	22.2	4558	19.5	15.5	5367
25% bark—75% wood	3.9	.970	18.8	13.5	4742	16.0	12.0	5438
50% bark—50% wood	3.6	.945	15.6	11.8	3834	14.3	10.4	3791
Birch, 100% wood	3.9	1.000	52.3	32.0	7952	43.1	26.6	7824
25% bark—75 wood	3.9	.985	47.9	27.1	5296	47.9	23.6	5353
50% bark—50% wood	3.9	.940	45.7	23.8	3806	38.1	19.3	4231

[1]Hardboards heat treated 3 hours at 165°C.

Actual plant equipment layout for the All-Board process.—*Photo courtesy Blaw–Knox*

pine board compositions met dimensional stability specifications, while none of the birch board compositions was satisfactory.

In referring to modulus of rupture, all bark-wood compositions met specifications except perhaps for the boards containing 50 per cent pine bark, which may be regarded by some as being marginal in this respect. However, it is the authors' opinion that a modulus of rupture of around 3800 psi is not necessarily submarginal, and many simple avenues are available to increase these values if they are considered significant.

In summary, these preliminary results indicated that both pine and spruce barks can be used in sizeable quantities in hardboard compositions in producing satisfactory products. Another interesting observation here was the fact that, when 50 per cent pine bark was used in the composition, the conventional sizing agent as well as heat treatment could be omitted and the resulting hardboard had excellent water absorption characteristics. This beneficial property of pine bark was not anticipated.

Why does pine bark exhibit this beneficial sizing property while this characteristic is absent when spruce and birch barks are used?

To answer this problem, a preliminary investigation was made as to the chemical composition of the bark components. Each of the ground barks was extracted consecutively with ethyl ether, hot water, and ethanol. The results are summarized in Table 4.

In this particular instance, the ether solubles would appear to be the most pertinent, since this solvent removes the resinous extractive components that would consist of resin and fatty acids, phenolic compounds, terpenes, sterols, esters, waxes, and the like. Since pine bark contains less ether solubles than the other barks, it immediately becomes apparent that it is not the quantity of ether solubles that determines the sizing properties of the bark, but rather the nature and quantity of certain components within the extract.

About 95 per cent of total extract removed by ether from birch bark was identified as the triterpene alcohol, betulin, $C_{30}H_{50}O_2$, m.p. 252° C. (9). This white crystalline substance, with its very high melting point, remains as an inert entity when incorporated in hardboard compositions. The very small remainder of the ethyl ether birch bark extract consisted largely of neutral organic compounds, in the form of saponifiable materials (esters), with a trace of free acidic components. This extract was not further investigated.

The ether-soluble extractives of pine and spruce barks were separated into their major component fractions, after removal of the water solubles removed during the extraction. The ether solution containing the extract was distilled and the residue was taken up in acetone and set aside in a refrigerator overnight to precipitate the waxes. The waxes were separated by filtration and the filtrate was examined for its remaining components by a scheme of analysis previously reported (10). The results are summarized in Table 5.

These data clearly show that spruce bark is richer in six of the seven components found in each of these barks. On the other hand, it will be noted that pine bark contained 1.68 per cent wax, m.p. 52–53° C., while spruce bark averaged only 0.31 per cent wax.

To get a further insight as to the nature of the sizing action (dimensional stability) entity in pine bark, some hardboards were prepared with bark that had been previously extracted with ethyl ether. The properties of the non-heat-treated bark hardboards so produced are summarized in Table 6.

It may be noted from these results that, while the unextracted pine bark produced a board with a low water absorption value of 20.1 per cent, the hardboards containing the same quantity of solvent-extracted bark had a high water absorption value of 60.4 per cent. Thus it would appear that it is the ether-soluble extract, largely waxes, that is responsible for the sizing action exhibited by pine bark.

In summary, it has been demonstrated that the properties of hardboards containing bark will vary, contingent, in part, on the nature and quantity of extractive components present. In the present investigation, it has been shown that the unique sizing

Table 4.—CONSECUTIVE EXTRACTIONS, IN PER CENT EXTRACT REMOVED

Bark	Solvent			Total extract
	Ethyl ether	Hot water	Ethanol	
Pine (*Pinus sylvestris*)	4.44	18.25	1.31	24.00
Spruce (*Picea abies*)	8.43	19.06	1.68	29.17
Birch (*Betula verrucosa*)	12.29	15.51	1.08	28.88

Table 5.—APPROXIMATE COMPOSITION OF ETHYL ETHER SOLUBLE EXTRACTIVES

Components	Pine bark		Spruce bark	
	In extract	In bark	In extract	In bark
	Per cent		Per cent	
Wax	43.9	1.68	7.3	0.3
Resin acids	8.0	0.30	22.9	0.9
Fatty acids	8.3	0.31	10.8	0.4
Phenols	3.1	0.12	2.9	0.1
Other acids	8.9	0.33	15.3	0.6
Saponifiable	16.2	0.61	22.8	0.9
Unsaponifiable	11.6	0.44	18.0	0.7
		3.79		4.1

Table 6.—PROPERTIES OF UNSIZED HARDBOARDS

Raw material composition	Water absorption	Thickness swelling	Modulus of rupture
	Per cent		psi
	24 hours	24 hours	
100% Pine wood	66.7	41.3	7180
50% Pine wood, 50% pine bark	20.1	12.9	4180
50% Pine wood, 50% ether extracted bark	60.4	28.3	3697

action of pine bark, when used in hardboard compositions, is largely due to the quantity of low-melting-point waxes it contains.

These preliminary investigations also indicated that pine bark, in particular, along with spruce bark, can be used in sizeable quantities with wood in producing a satisfactory commercial hardboard. The use of more bark in fiberboard manufacture would help to alleviate the problem of the economic disposition or use of bark residues, and hence extend the use and economic recovery of the timber resources. This is particularly true in the Scandinavian countries, where intensive forest products industry practices are being employed in which timber resources are being extended to maintain present industries (11).

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Milling Redwood Bark[1]

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Redwood bark fiber was studied as a furnish for insulation board as far back as 1929. Trials since then with disc refiners, hammermills, attrition mills, screw presses, and defibrators are described.

This modified screw press, similar to those used in expressing cottonseed oil, can remove 92 per cent of the dissolved solids from redwood bark.

RECORDS SHOW THAT Bauer equipment first processed redwood bark April 29, 1929. The objective was to explore the use of redwood bark fibre as a furnish or partial furnish in making insulation board for the Pacific Lumber Co. These first tests certainly did not prove completely satisfactory, although considerable knowledge was derived from the test work. The results did not indicate merit in further study. Double and single revolving-disc refiners were used in these tests.

In September of 1929, further demonstration tests were made, with the objective still being to develop methods of treating redwood bark to make it useful as a component of insulation board. Again, the results continued to indicate possibilities but the quality of test boards did not quite come up to acceptable standards. The same equipment was used in these tests as had been used earlier, but the procedures were modified.

Another series of tests was run in December, 1930. The results were only mediocre. For the next 10 years, there was no further activity directly involving Bauer Bros. with respect to processing redwood bark. However, in August, 1940, General Electric Co. sponsored some work with the objective of fluffing groundwood lap pulp and redwood bark, not in combination. In this case, the bark was processed in a hammermill operating at 3600 rpm, and was dressed with both 1/4-inch and 3/16-inch perforated screens. The test report states that representatives of General Electric were satisfied with the results attained.

In June, 1947, under the sponsorship of the Institute of Paper Chemistry, further milling demonstrations were made with the objective of producing as fine particles of redwood bark as possible. In this instance, half of the bark was milled on a No. 182 hammermill at 3600 rpm and dressed with 1/32-inch perforated screen. The other half was milled on a No. 165 double revolving-disc attrition mill at 1800 rpm and dressed with B-950 plates. The screen analysis of results from both were as follows, as analyzed by 15-min. Tyler Rotap apparatus:

Screen mesh	% Retained (H. mill)	% Ret. (Att. mill)
Plus 35	1.4	Trace
Plus 65	19.3	4.9
Plus 80	7.7	3.1
Plus 100	12.2	7.5
Plus 200	37.3	40.5
Plus 325	15.5	26.8
Minus 325	6.6	17.2

[1] Presented at the Spring Meeting, FPRS Northern California Section, May 1-2, 1958, Berkeley.

In October of same year, further demonstration tests were made, sponsored by the Institute of Paper Chemistry. The objective was to reduce particles to fine particle level in the first instance, and to separate fibers in the second instance. In the succeeding years, additional tests have been made. Both pulping techniques and low-moisture-content fiberizing have been used. The objectives have varied from a wood-flour-like material to fiber for producing insulation board.

Not too long ago, additional work was performed with a newly developed screwpress called a "Pressafiner" to express water solubles from redwood bark. This screw press is similar to those used in expressing oils from cotton seed. It has been modified to withstand the punishment of continuous operation on such materials as raw wood chips or partially cooked wood chips. By two stage processing, 92 plus per cent dissolved solids can be removed. A portion of these solids represent some chemicals used in cooking the bark prior to pressing.

A machine developed for separating short lint from cotton seed hulls seems to have a potential in the milling of redwood bark. This device has the ability to fiberize fibrous materials in air suspension. By selection of rotating element speeds, air velocities through the machine, hammer patterns, pretreatment of the bark, and so forth, it may be possible to produce a range of fibers (long fibers for textile purposes to short for assorted purposes).

Some limited trials were made, and the results were far from discouraging. The bark was sawed to lengths of 1½ to 2 inches and broken by hand, and was then steamed at atmospheric pressure until a moisture content of 50 per cent was reached. This moistened material, when fed to the machine, produced a split of about 50–50 between the fibers aspirated out of the machine and the material that dropped through the annulus screen directly below the action zone of the rotating hammers.

The speed of the rotating element was 1200 rpm in this instance, and air velocity was about 1800 fpm.

This trial justifies further work. Among other things that should be explored are: increasing air velocity, changing rotating element speed, various steaming and chemical pre-treatments, and so forth.

In summary, there is sufficient evidence of potential end uses for redwood bark. This fact, coupled with the ever increasing fund of knowledge on the technology of processing bark, in conjunction with new equipment developments, warrants serious and active commercial interest.

RECOVERY, PREPARATION, AND Yields of

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Since redwood logs may be up to 20% bark, utilization must be stepped up. Here, the essentials of initial bark removal, recovery, and processing are described.

THE GREAT SIZE OF REDWOOD TREES is both a boon and a bane to loggers and sawmill men. Part of the difficulties involved in handling the giant logs results from the nature of redwood bark. Its exceptional thickness and toughness are essential to the longevity of the trees, but the very characteristics of the bark that help the redwood tree achieve its size create problems in its conversion to lumber.

Much has been written about the reasons for removing bark from redwood logs before they enter the sawmill. Overheating and smoking of saws in the cut, clogging of conveyors, and safety considerations are but a few of the very valid reasons for debarking.

In 1942 and 1944, a study was conducted in which sawing times for peeled and unpeeled logs were compared. From the study it appeared that there was little significant difference in saw time per MBF, between peeled and unpeeled logs, until the logs reached a diameter of 40 inches. Unpeeled logs over 40 inches in diameter took 50 per cent more time per M to saw than peeled logs. The over-all average for unpeeled logs was 5 per cent longer per M than for the peeled logs. It is beyond the scope of this paper to discuss these factors. It is timely, however, to summarize current practice of removing bark and subsequently processing it for disposal as a waste product or for further refinement into salable products.

Debarking Methods

During the infancy of logging in the redwood reigon, practically all bark removal, when practiced, was in the woods. Today hand barking is practiced by a number of companies, and this method has its place under certain conditions. Investment for woods debarking equipment is low; it consists of a peeling bar, axe, and a husky peeler. Since, as a general practice, the bark peeled from logs in the woods is not further handled, little need be said of the yield of bark or its subsequent processing. Suffice it is to say that bark removal in the woods accomplishes the principal objective, namely that logs are delivered to the mill in a form that permits more efficient sawing.

There has been an increasing trend toward bringing logs to the mill site for debarking. The principal advantage gained in hand debarking at the mill site stems from the opportunity to handle the log mechanically. This in turn permits more complete debarking and decreases the hazard of the operation. Each mill has developed its own system of handling. Efficiency of operations vary considerably, depending on the amount of mechanization involved. Specific yields of bark will be discussed separately.

Removal of bark with mechanical debarkers has been limited in the redwood region. The large and often irregular shape of redwood logs and the fibrous nature of the bark have been the principal deterrents to the use of mechanical debarkers. Only one design of mechanical debarker has been used on redwood logs with any degree of success.

The latest development in the removal of redwood bark has been the hydraulic whole-log debarker. One is

[1] Presented at the Spring Meeting of the Northern California Section, FPRS, May 1–2, 1958, Berkeley, Cal.

Redwood Bark[1]

Removing bark by hand is a two-man job in the redwood region.

stallation has been in operation successfullly for several years; another is currently under construction. Large capital investment, adequate water supply, and sufficient mill cut are all factors that govern the installation of a hydraulic debarker. The tough nature of redwood bark requires adaptation from standard designs of hydraulic debarkers.

Yield of Redwood Bark

The yield of redwood bark depends on a number of different factors, of which method of debarking is probably one of the most important. Any discussion of yield must be tied in with the form of bark. Hand-peeled bark differs from mechanically removed bark, and both differ in appearance from hydraulically removed bark. The amount of wood that adheres to the bark after each of the debarking methods varies considerably.

Another factor that substantially influences the yield of bark as measured by weight is the per cent of water in the bark. The amount of water in the bark depends principally on the method of sorting logs and how the bark is removed from the log. Additional varying factors governing bark yield are size of timber, logging area, and amount lost in handling; more loose summer bark is lost than the tighter winter bark.

Data reported on yields of redwood bark have been somewhat confusing in the past. Two methods of measuring have been used; cubage as measured by cords and weight measured in pounds or tons. Also both Spaulding and Humboldt log scales have been used as a basis. For the sake of this discussion, weight of bark per MBF of logs Humboldt Scale will be used.

Yield of bark from a thousand board feet of logs, Humboldt Scale, has been reported to be 500 to 1000 pounds, wet basis. With the percentage of water in bark varying from 30 to 40 per cent on the tree to about 50 per cent in average hydraulically removed bark and on to 70 per cent or more in hydraulically removed bark stored in the open during the wet season, it is easy to understand why it is not wise to arrive at a bark yield figure that will apply to all conditions. Each company must determine its bark yield under its own specific operating conditions.

Preparation of Bark for Processing

The handling of bark once it is removed from the log is governed to a large degree by its intended use. In the majority of cases, redwood bark is disposed of as a surplus product, usually by burning. Bark removed by hand or mechanically presents no serious problem in disposal. Well-soaked or hydraulically removed bark, however, is difficult to burn. The use of blowers and addition of wood to the pile are often necessary to achieve satisfactory combustion. When redwood bark is used to generate power, only a limited amount can be mixed with the other types of fuel.

Preparation of bark for processing into salable products is most simple in those mills which sell the bark to the final processing plant. All the bark sold for further processing is either hand peeled or mechanically removed. Usual procedure is to load the bark in loose form in a truck or gondola car and remove it mechanically at the destination. Some experiments with steel strapping of unit packages and other consolidation of bark into units are underway.

In the actual bark processing plant, bundling of the bark depends on its form. Hand-peeled bark tends to be more in slab form. Hydraulically removed bark is in smaller pieces and the individual pieces are fairly well interlaced. Both types of bark are delivered to the initial point in the processing plant by conveyor. Hand-peeled bark, because of its slab nature, is usually fed into a horizontal hog. Hydraulically peeled bark can be fed either horizontally or vertically to the hog. Hydraulically peeled bark, because of its wetter form, is usually allowed to stand for some time before it is processed to permit surface water to run off.

A brief description of an initial processing operation is of interest. This description will be limited to a hydraulic bark-removal operation.

Redwood logs passing through a modified Bellingham debarker require from 30 seconds to 5 minutes or more to be peeled, depending on the size

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Stockpiled bark moves into the bark conversion plant (Chemical and Fiber Division) at Union Lumber.

and shape of the log. Although approximately 400 redwood logs are processed in an 8-hour shift, this is not the capacity of the debarker. Peeling of redwood at the foregoing rate may yield form 60 to 100 or more tons of bark a day on a two-shift basis. Production through the debarker is intentionally kept in line with the sawmill's ability to utilize the logs. It has been estimated that at full capacity the debarker might process 1,000 or more medium Douglas–fir logs.

To handle quantities of bark of this magnitude, it is essential that the majority of operations be mechanized. The bark drops from the debarker onto a chain conveyor, which travels approximately 100 feet to a primary hog. Much of the free water added by the debarker is lost during the transport. To facilitate subsequent handling, the bark is processed at the sawmill through a large swing-hammer type hog in which the long strips of bark are reduced by a single 1-inch bar.

From the sawmill the bark is transported to the processing plant and is fed through a second swing-hammer type hog. In this operation, the bars of the hog are spaced 2 to 3½ inches apart, and the bark is cut and fluffed up for movement by air to the actual processing into salable products.

No attempt will be made here to describe the details of the working of the bark in the processing plants. Beyond the point of initial reduction in particle size, as accomplished by the hogs, each manufacturing plant differs in its methods. Some mention of yield of different size bark fractions as obtained in a bark processing plant may be of interest, however. It should be remembered that the following broad classifications of bark are further refined and some are chemically processed before the salable product is finally produced.

Redwood bark is composed of an exceptionally large amount of long, resilient fibers. With proper care, long fibers that range from ½ inch to 3 inches and more can be recovered from processed bark in the range of 20 to 40 per cent of the total input into the processing plant. The non-fibrous type fraction, sometimes called the scale fraction, which is derived from the small amount of sapwood, inner bark, and extreme outer layer of bark, constitutes about 5 to 15 per cent of the total yield. The remaining fraction of the bark consists of short fiber, grading from ½ inch in length to an essentially non-fibrous dust-like particles. About 30 to 60 per cent of the processed bark is in this form. This fraction is further refined, of course, into different size components.

Variations in yield of different fractions from the bark depend on seasonal factors of log cutting and storing, size of log, age of bark, method of debarking, bark storage, its moisture content at time of processing, and the emphasis on end-product as governed by quantity of bark fraction used. It is possible to influence the yield of different bark fractions, particularly in the shorter components, by the manufacturing method.

Most bark is removed hydraulically at Union Lumber.

Further Development in Bark Removal

In recent years, the problem of bark removal and subsequent utilization has been given an ever-increasing amount of attention by companies that manufacture redwood lumber. This development applies both to the basic problem of bark removal as well as further refinement into salable product.

Most mills are now either considering or actively pursuing the removal of bark at the mill. Greater activity is evident in the field of bark processing. Experimentation is underway on radically different methods of processing bark once it leaves the debarker. Also, further refinement of the bark fractions is being developed by several companies. It is safe to say that the next few years should see a more thorough utilization of redwood bark. The whole lumber industry is intensely active in its efforts to get whole-log utilization; it is inevitable that a component such as bark, which may constitute as much as 20 per cent of the log, will be the subject of such additional research and development.

HORTICULTURAL APPLICATIONS FOR

Bark and Wood Fragments[1]

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Bark and wood fragments can have these horticultural uses: as a growing medium; to alter soil–water–air relationships; to lower bulk density; to improve friability; and act as a protective mulch.

WITHIN RECENT YEARS, there has been a marked increase in the use of bark and wood fragments for certain horticultural applications. In general, these wood products have been considered to be substitutes for various types of peats and mosses that, for many years, have been valued as growing media, amendments, and mulches. Consumer cost for sphagnum peat moss now usually amounts to about $10 per bulk cubic yard and up, and as long as wood and bark fragments can be purchased at considerably lower prices, there is little doubt they will continue to furnish strong competition in the horticultural market to peats and similar materials.

The following list comprises the principal purposes that coarse organic amendments serve in horticultural applications:

1. As a growing medium.
2. To alter the water and air relationships of soil mixes, particularly for container growing.
3. To lower the bulk density of a growing medium.
4. To improve friability and minimize crusting of soils.
5. As a mulch for reducing evaporation, to protect the soil surface, control weeds, or for decorative purposes.

The principal disadvantage to the use of bark and wood fragments has been the draft induced on the nitrogen supply in the soil. In a few cases, as discussed in greater detail below, some toxicity may result.

This paper will review previous work on the effect of bark and wood fragments on plant growth, and discuss various other questions regarding their horticultural use. Data on the relative nitrogen draft produced by certain barks and woods as well as their effect on certain physical properties of soil mixes will be presented.

Wood and Bark Fragments as Growing Media

The production of certain specialty horticultural crops is usually accomplished in organic growing media. Examples are orchids, azaleas, and ferns. The reasons for the favorable response in this type of a root environment are not entirely clear. It may be due to the susceptibility of the roots to pathogens unless maintained in relatively dry conditions, high oxygen requirements of the roots, nutritional factors obtained from the organic matter, such as certain of the B vitamins, or favorable pH conditions in the organic matter environment. In any event, there appears to be no reason, provided certain precautions are taken in maintaining the nitrogen supply, and sometimes in controlling the acidity, why many types of bark and wood fragments will not serve equally as well as the peats and leaf molds so widely used as growing media. Initial grower response to the use of bark fragments of white fir *(abies concolor)* and other similar materials as growing media for various types of orchids was enthusiastic. Recently there have been some problems developing from decomposition of the barks with resultant loss of structure and from heavy infestations of insects, arthropods, and other pests in the barks. It is not clear if the problems of decomposition and pest infestation are more serious with barks than with various types of mosses or not. In summary, it appears that nearly all types of wood and bark fragments can serve satisfactorily in horticultural applications in short-term growing operations up to about three years provided nitrogen relations and acidity are properly controlled.

The possible limitations as compared to other organic materials when used in long term growing operations such as orchids needs further study.

There may be, of course, certain plants that do not respond well in the presence of certain barks or wood. For example, Lunt (4) observed that snapdragons gave a small negative response when chips were used, even though supposedly sufficient nitrogen was applied. Enough work has accrued, however, to indicate that negative response, except as may develop in long-term use as rated above, should be considered exceptions to the rule when sufficient nitrogen is used with bark and wood amendments.

Toxic Constituents in Wood and Bark Fragments

The belief is apparently wide spread that many woods or barks contain agents that are toxic to plants. With few exceptions, this belief probably stems from observed suppressions in growth due to nitrogen deficiency induced by the wood materials (1, 2, 4, 7). A few wood products do contain sufficient toxic materials to substantially retard growth. The authors have observed a marked retardation in the growth of tomatoes in mixes containing walnut or cedar shavings. Incense

[1] Presented at the Spring Meeting of the Northern California Section, FPRS, May 1–2, 1958, Berkeley, Cal.

[2] Appreciationis expressed to the following organizations, which supplied materials used in some of these studies: Ivory Pine Co., Big Bear Timber Co., Union Lumber Co., Diamond Match Co., Michigan–California Lumber Co., California Cedar Products Co., and Long Beach Shavings Co.

Table 1.—FRESH WEIGHT OF CORN GROWN ON VARIOUS SOIL MIXES EXPRESSED AS A PERCENTAGE OF THE YIELD OBTAINED WITH A SPHAGNUM PEAT MIX

Bark or wood source used in soil mix[1]	Corn yield as percentage of that of peat mix	
	No extra N	N fertilized
Jeffery pine bark	27	97
Sugar pine bark	72	91
Ponderosa pine bark	28	108
"Pine shavings"	61	84
Douglas-fir bark	48	88
White fir bark	72	100
Red fir bark	41	96
Redwood bark	83	91
Redwood shavings	60	81
Incense cedar bark	71	66
Philippine mahogany shavings	67	91
Sphagnum peat	100	100

[1]The mixes were prepared by blending equal parts by volume of krilium-stabilized Pleasanton silt loam and the wood or bark amendment. The following quantities of fertilizers were added per gallon of mix: 20 grams of dolomitic limestone; 5 grams of single superphosphate; 1 gram of Dura-K, a potassium fertilizer. In the cases where nitrogen was supplied, 2.4 grams of nitrogen were applied per gallon of mix from an "ammoniated sawdust" source known to supply nitrogen readily for a period of about six weeks. A liquid fertilizer containing nitrogen was also used for irrigation.

In the trials that did not receive nitrogen, corn was grown in containers of one and one-half quart capacity for six weeks, at which time slight nitrogen deficiency was apparent even in the peat mix. The trial in which extra nitrogen was supplied lasted two months, and was conducted in gallon-szie containers. Both studies were made under greenhouse conditions.

cedar bark and redwood shavings are mildly toxic (see data in Table 1). Redwood shavings and sawdust are widely used by the ornamental industry in California, and the mild toxicity that can be demonstrated appears to be of little consequence even when used in quantities up to one-third by volume in soil mixes. There appear to have been a few cases of serious injury from redwood shavings when used as high as 50 per cent by volume, particularly following steam sterilization.

On the other hand, conccentrations of 50 per cent or more redwood shavings in a mix have often been innocuous. These discrepancies are probably related to the amount of aging and leaching the shavings or sawdust has been subjected to. Plant toxicity around the margins of new redwood flats is often observed. This toxicity is reduced to negligible proportions by the time the flat is used a second or third time.

The toxic nature of walnut and cedar wood and bark is substantiated in the literature (1, 4). In addition, sawdust from gum, mahogany, iron, bark, messmate (8) and leaves and needles from certain species seem to be mildly toxic (3).

Nitrogen Deficiencies Induced by Wood and Bark Fragments

When wood and bark fragments are incorporated in soils, they furnish various organic materials that are readily used as energy sources by micro-organisms. As proliferation occurs, the micro-organisms draw heavily upon the nitrogen reserves in the soil since the natural wood materials are invariably deficient in nitrogen, and as a consequence higher plants that are competing with micro-organisms for available nitrogen may suffer from nitrogen deficiency.

Table 1 summarizes data on a number of bark sources available on the Pacific Coast, as well as certain other wood sources regarding their ability to produce a draft on the soil nitrogen supply. These data show the large depressions in growth that can result from large incorporations of bark and wood fragments and, likewise, indicate that these can be largely overcome by adequate nitrogen fertilization. In the second column, the yield of corn is expressed as a percentage of that obtained on a peat mixture since peat results in negligible nitrogen draft on the soil. Those materials which result in large depressions in yield probably have the largest quantity of quickly available energy sources for micro-organisms. The data in the third column of Table 1 show that growth depression can be largely overcome by nitrogen fertilization with the exception of incense cedar bark and redwood shavings, in which mildly toxic agents were apparently present.

A classification of the materials in Table 1 on the basis of producing nitrogen deficiency is as follows:

EXTENT OF DEPLETION OF SOIL NITROGEN BY VARIOUS WOOD AND BARK SOURCES

Large	Intermediate	Small
Ponderosa pine bark	Philippine mahogany shavings	Sphagnum peat
Jeffery pine bark	"Pine shavings"	Redwood bark
	Redwood shavings	White fir bark
	Douglas-fir bark	Sugar pine bark
	Red fir bark	Incense cedar bark

The above data should only be taken as approximate guides to the relative amount of nitrogen deficiency that might be induced by different materials in actual practice since rainfall or washing might be expected to reduce the effect.

Considerable information on the relative nitrogen draft caused by wood and bark fragments is dispersed through the literature. Bollen and Lu (2) observed that ponderosa pine sawdust exerted a large draft on soil nitrogen, but Douglas-fir bark and sawdust that were about equal in their effect caused a much smaller draft on soil nitrogen. Salomon (7) showed that ten tons of white pine *(Pinus strobus)* per acre caused a substantial reduction in the yield of beets and spinach when no nitrogen was added, and that black oak *(Quercus valutina)* caused a larger reduction in soil nitrogen during the first 90 days than did pine chips. These two woods should be classified as producing a relatively large draft on soil nitrogen. Lunt (4) found "red and white" pine chips to decompose much more slowly than "oak" which, in turn, was slightly slower than grey birch. The magnitude of nitrogen deficiency was proportional to the rate of decomposition.

The duration of induced nitrogen deficiency varies with the rate of application of amendment. Extremely large applications may induce a draft on soil nitrogen that may be noticeable for several years. Salomon (7) found that an application of ten tons of sawdust per acre (about 7½ per cent on a volume basis if mixed into the top seven inches) does not usually depress yields as compared to a control plot after about four months to one year from the time of application, even though no nitrogen had been applied. In horticultural and landscaping operations, rates of use of organic amendments typically run from 1/10 to 1/3 on a volume basis, and may usually be expected to cause a nitrogen draft for periods of six months or more.

The nitrogen deficiency caused by woods and barks presents a problem regarding their use—but it is one that can be overcome by education. Even a professional grower is very apt to become a victim of nitrogen deficiency the first time he uses wood or bark in a soil mix. In the production of extremely short-term crops such as some flatted nursery stock that is produced in six weeks or less, bark or wood fragments must be used with caution since a reduction in growth may occur if nitrogen becomes deficient.

There are no serious drawbacks to the use of bark or wood fragments as ingredients of soil mixes in longer term crops, such as carnations or roses. Ultimate decomposition may limit usefulness to about five to seven years. When barks or woods are used in landscaping operations, the person or maintenance organization should be well aware that an extra draft on the soil nitrogen is to be expected. Of the bark materials listed in Table 1, sugar pine, white fir, and redwood are most desirable because of their relatively small draft on soil nitrogen. Redwood bark is difficult to handle, however, because of its fibrous nature.

A consideration of importance is the amount of nitrogen required to maintain the nitrogen balance when wood or bark fragments are used. This requirement will vary from material to material, but a number of investigators have found that about one pound of

actual nitrogen per 100 pounds of dry wood or bark fragments is required (1, 4, 7). Preferably, the supplemental nitrogen should be added in three or four portions. This extra nitrogen required to maintain a nitrogen balance thus adds about 50 cents to one dollar to the cost of a yard of wood or bark chips. The dry weight of wood or bark fragments usually runs between 300 and 450 pounds per yard, and the cost of inorganic nitrogen usually falls between about 13 and 20 cents per pound of nitrogen when purchased in quantity. Anhydrous ammonia may be obtained at even lower prices.

It is possible to treat wood and bark fragments with nitrogenous materials so that they do not produce a nitrogen deficiency when used. "Noyo Soil Booster", for example, did not produce a nitrogen deficiency when used in greenhouse tests.

Mineral Composition of Barks and Woods

Table 2 summarizes spectrographic chemical data on the chemical composition of barks from three different species. The question is often raised as to the effect of bark and wood fragments on the nutrition of a planting other than its effects on nitrogen supply. Several writers (1) have emphasized the contributions of minerals from woods or ashes; calcium, potassium and phosphorus being the principal constituents.

Table 2.—SPECTOGRAPHIC ANALYSES OF THREE BARK MATERIALS[1]

	Percentage by weight		
	White fir	Sugar pine	Ponderosa pine
N	0.22	0.14	0.13
P_2O_5	.20	.03	.02
K_2O	.10	.04	.04
CaO	1.33	.19	.29
Ash	2.90	.53	.77
pH	4.3	3.3	4.0

[1]Supplied by the Ivory Pine Co.

In horticultural and landscaping use, the immediate contribution to macro nutrient supply and micro nutrient availability are the problems of greatest concern. A large number of micro nutrient elements are present in barks and woods in trace amounts, but their contribution to the minor element nutrition has not been studied. In certain cases, potassium and phosphorus derived from the bark appear to make a contribution to the planting for a period of a month or so, but by and large the principal effect of barks and woods on the macro element nutrition of plantings in soil mixes is that to be expected by diluting the soil with relatively inert materials; in other words, more frequent fertilization is generally required.

It is noteworthy that bark and wood fragments have cation exchange capacities of considerable magnitude that would tend to minimize leaching losses of cations. When the cation exchange capacity from bark and wood is computed on a volume basis in the soil mix, however, this contribution is less impressive. Lunt (4) found oak chips to have an exchange capacity of 76.8 m.e./100 grams. At the UCLA laboratory, white fir bark was found to have an exchange capacity of 11.5 m.e./100 grams.

Effect of Wood and Bark Fragments on the pH of a Soil Mix

Most barks and woods are acidic. Fresh fragments have pH values that range from about 3.5 (approximate pH value of many peats) to about 7.0 (6). It is a common observation, however, that soil pH has been affected but little by the incorporation of 30 tons of chips per acre after a period of a year or two (6, 7).

The short-term effect of bark or wood fragments on the pH of a soil mix will depend on the nature of the soil, particularly whether it is calcareous or not, and the amount of amendment used. In those cases where it is desirable to maintain the soil pH at levels near neutrality, the use of ten pounds of agricultural limestone per yard of bark or sawdust is satisfactory. The barks of Douglas-fir, incense cedar, red fir and white fir are the most acidulating of the materials reported in Table 1.

Longevity of Bark and Wood Fragments in Soils

There is a paucity of quantitative information on the longevity of various bark fragments in soils. Considerably more information is available on the rate of decomposition of woods. Salomon (7) reported the percentage of added pine chips larger than 2 mm remaining one year after incorporation in a soil ranged from 24 to 34 in various treatments and from 7 to 16 per cent after two years. Similar percentages for oak chips remaining were 7 to 9 and 2.5 to 3.5. Bollen and Lu (2) observed that Douglas-fir bark was slow to decompose, and suggested this was due to a relatively high lignin content.

The experience of the authors with white fir bark and redwood bark and sawdust is that these materials are slow to decompose and can be expected to persist for periods of at least several years in horticultural applications. Pine and fir *woods*, on the other hand, decompose relatively rapidly, but when used in large quantities markedly alter physical properties of soils for periods well beyond a year (5).

Influence of Coarse Organic Amendments on Certain Physical Properties of Soil Mixes

The particle size of an organic amendment has a large influence on water and air and other relationships that develop in soil mixes. Salomon (7) found depressive effects on plant growth persisted longer from wood chips larger than one-quarter inch in diameter than from smaller chips.

Quantitative data are not available on the most desirable size for wood fragments for various applications as amendments. For most uses, a distribution in fragment sizes ranging from about 8 mm down to 1 mm in one dimension appears to be quite satisfactory. When used as the principle ingredient in a growing medium, as in the case of orchids, the inclusion of a large amount of fragments larger than the range mentioned above seems to present no problems and may be desirable. The orchid plant stores water, however, and the roots are capable of remaining quite dry for a day or two at a time.

If the soil surface is diluted with a sufficient quantity of peat, the tendency of the soil to form a crust can be eliminated. In this application, bark and wood fragments are as effective as peat. Likewise, in landscaping operations it is frequently desired to improve the tilth of fine-textured soils by the incorporation of large quantities of peat. Initial infiltration rates are usually increased by this procedure also. Here again, bark and wood fragments are generally as satisfactory as peat.

There is a widespread misconception that the incorporation of coarse organic amendments increases the water-holding capacity of the soil. This is not true if the soil is about three or four feet deep and moisture content is calculated on a volume basis. On the contrary, moisture-holding capacity is decreased and usually evaporation rates are increased unless a mulch is also used.

Organic Amendments for the Production of Container-Grown Stock

One of the large uses of organic amendments in the horticultural field is in the production of container-grown nursery stock and cut flowers. Under these shallow-soil conditions, amendments are used to alter water and air relations in the mixes dramatically and to lower the bulk density. Laboratory characterization of the mixes show wood fragments can serve as success-

fully as peat as soil amendments. Care must be taken that particle size is not too coarse. Excessive drainage is often achieved with shavings. Lunt and Kohl (5) obtained remarkably uniform production of carnations on various soil mixes in which Krilium, pine or redwood shavings, white fir bark, sphagnum peat, or pumice served as the soil amendment.

When plants are grown in containers, the soil depth is, of course, limited by the depth of the container, and unless the container is about three or more feet deep, some degree of shallow-soil conditions prevail. When the depth of the soil column is short, the amount of water retained by the soil when drainage from the bottom of the container ceases is much greater than if deep-soil conditions existed. The use of coarse organic amendments under shallow-soil conditions usually increases both the water and air content of the mix, and lowers the bulk density as well. Table 3 summarizes the air and water relations prevailing in soil columns eight inches deep when drainage ceases after a thorough wetting. These figures were obtained from moisture-retention curves. Bulk densities of various amendments and mixes are also presented. The mixes had been in use for more than a year and one half. The higher bulk densities for the pine shavings mix as compared to redwood shavings reflects much greater decomposition of the pine shavings.

The data in Table 3 show that wood shavings may be about as light as peat, whereas sawdust or bark will be heavier. Available water retention (water than can be removed by a suction of 15 bars is considered to represent that available to plants) by peat is relatively high. The bark or wood fragment retention is determined by particle size. The data pertaining to the mixes show that the wood and bark amendments greatly increase the water retention in short columns, although not quite so much as peat, and at the same time increase the air space in the mix generally somewhat more than peat. Bulk densities are decreased to about the same degree as peat when materials are used which decompose slowly.

It is clear from these data that bark and wood fragments produce about the same effects on certain of the physical properties of soils as does sphagnum peat, and therefore, from this point of view serve equally well as soil amendments.

Table 3.—BULK DENSITIES,[1] AND AIR AND WATER RELATIONSHIPS IN 8-INCH COLUMNS WITH AMENDMENTS USED ALONE OR MIXED WITH AN EQUAL PART BY VOLUME OF SOIL

Amendment or soil mix	Particle size	Weight per cubic foot, pounds	Per cent air space when drainage ceases following an irrigation	Available water as per cent of total volume
White fir bark	<½"	25.5	26	28
Sphagnum peat	<⅛"	8.1	24	44
Pine shavings	<½" long	9.8	29	47
Perlite	<⅛"	7.5	46.5	20
Sawdust	<⅛"	25	32	30
Vermiculite	<¼"	8.1	35	30
Pumice	<¼"	30.5	55	15
Pleasanton silt loam		95	1.5	26
Pleasanton + Krilium		82.5	5.5	31
Pleasanton + pine shavings		67	9.5	39
Pleasanton + redwood shavings		50	15.5	42
Pleasanton + white fir bark		57	8.5	39
Pleasanton + sphagnum peat		52.5	6.5	46
Pleasanton + "Crownite" pumice		69	9.5	36

[1]The bulk densities are dry weights. The water and air contents are average values obtained for loosely packed columns **eight inches in height** when drainage ceases following a thorough wetting. Krilium was used in the usual manner at the rate of 0.1 per cent by weight. Data for the mixes were obtained on undisturbed cores from sources that had been in use for a year and one half.

Summary

Bark and wood fragments can be used successfully for many horticultural applications, including growing media for certain plants, amendments in light-weight soil mixes usually used for container growing, soil amendments in landscaping operations (field soils), and for mulches. Bark and wood fragments, when used in the large quantities typical of horticultural applications, induce large drafts on soil nitrogen reserves, and this represents one of the greatest problems regarding their use. Ammonification or other nitrogen treatment of bark and wood fragments offers a means of minimizing this problem. The nitrogen draft may persist for periods of two years or more where heavy applications are made.

A classification of several bark and wood materials on the basis of the magnitude of nitrogen draft produced is presented. Although marked differences exist between materials on the extent of nitrogen draft induced, as a general rule an extra pound of nitrogen per 100 pounds of dry fragments is required to maintain nitrogen balance. Preferably this should be applied in several split applications.

Ultimately, barks or wood fragments have little effect on the soil pH, although initially they may increase acidity considerably if used in large quantities. If it is desired to control pH shifts, the use of ten pounds of limestone per cubic yard of fragments is suggested.

Some barks supply significant amounts of potassium, phosphorus, and calcium for short periods, but in general it is believed they have small effects on macro element nutrition, excluding their effect on nitrogen supply except as they dilute the source of minerals in the soil.

With few exceptions, notably walnut bark and wood, cedar bark and wood, and to a slight extent redwood, barks and woods are essentially nontoxic to plantings. Longevity of fragments varies with different amendments. A few qualitative observations are made.

The effect bark and wood fragments have on certain physical properties of soil mixes depends on the size of the fragment, but it has been shown that fragment sizes in commercial use have effects that are in general very similar to those of peat. Under deep-soil conditions they reduce the water-holding capacity, but improve the aeration and generally improve the tilth, particularly of fine-textured soils. Under shallow-soil conditions, bark and wood amendments increase both water-holding capacity and air space, and lower the bulk density.

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INFLUENCE OF SPECIFIC GRAVITY AND RESIN CONTENT ON

Properties of Particle Board[1]

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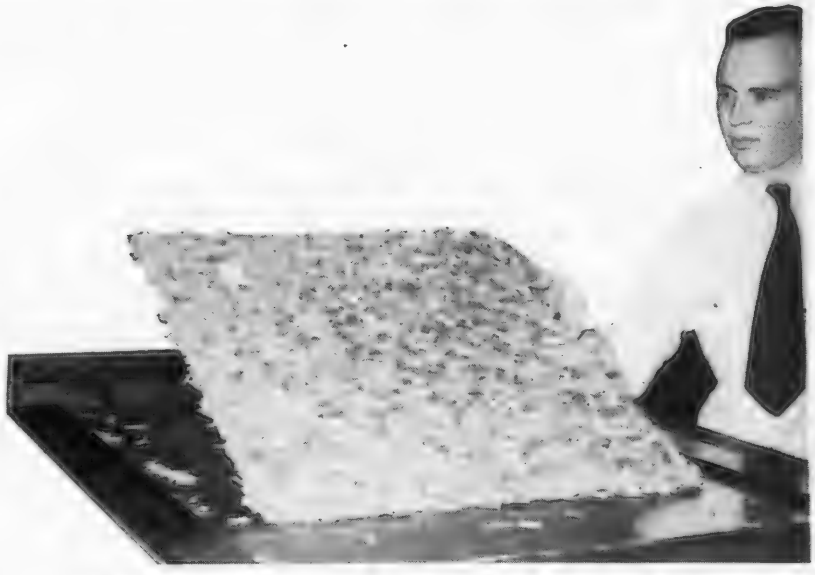
Aspen and yellow birch flake boards were studied to determine effects of wood specific gravity, resin content and board density on strength and stability. Aspen boards were stronger and more stable. Boards with more resin expanded less.



The author inspects a yellow-birch flake board as it comes from the press.

A WOOD PARTICE BOARD is composed of essentially dry wood particles that have been coated with a resin binder and pressed into shape.

Particle board was first introduced as a commercial product in Germany, in 1948. It was originally produced to utilize wood waste. Now, in many situations, particle board manufacturers are using wood from the tree, rather than from some waste source. With this occurring, it is evident that a product has been developed, not solely as a utilizer of waste, but as a new product for new uses.

There are several basically different methods of production, and many variables within each method. It is not within the scope of this paper to outline these methods or all of the variables. An effort will be made to investigate some of the basic variables that are always present. These basic variables influence the mechanical properties of particle board.

At the present time, there is little or no standardization of mechanical properties. A prospective user of particle board can not consult a simple table to determine the mechanical properties, as he would with steel or aluminum, or even with wood. In most cases it would be difficult to determine these properties, even from the manufacturers, and in some cases the only source of such information would be through a series of tests made privately.

Klauditz (5)[2] carried out research on the modulus of rupture in bending for varied board specific gravities and for different species. Actually, the work involves the difference in species, which have many variables in themselves. The average specific gravities for each wood could be assigned, and a comparison might then be made between wood specific gravity, board specific gravity, and strength, but such factors as wood specific gravity and board resin content were not varied. The work that has been done on the interrelationship of fabricating variables and mechanical properties is not conclusive.

Turner (8) carried out further basic research on the effect of particle size and shape on the strength and dimensional stability of wood particle boards. In this work, Turner tested boards of various specific gravities made up with different percentages of synthetic resins. Different species of wood with varying specific gravities were also used in the study. Turner made no attempt to correlate the strength properties with all three factors of varying wood specific gravity, resin content, and board specific gravity. Turner's work was primarily an investigation on particle shape. He did find, however, that board density was of primary influence and that resin content was of secondary influence in controlling strength properties.

The simple relationships between strength and resin content, strength

[1] A 1958 Wood Award entry, submitted while the author was a graduate student at Michigan State University.

The Author: F. Dale Larmore holds BS and MS degrees from Michigan State University. Before joining Westvaco, he also spent some time working at the U. S. Forest Products Laboratory.

[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.

and board density, and strength and species are known .

Without more detailed basic research in the particle board field, it will be difficult to predict and establish any kind of standardization as concerns the physical properties of particle board.

The majority of particle boards made in the United States utilize softwoods because there has been more softwood waste available. Some manufacturers are making boards from hardwoods now, and consequently it is important to learn more about the use of these woods in particle board.

Objective

The objective of this study was to determine the character of the relationships between the three factors: 1) specific gravity of the wood; 2) specific gravity of the particle board; 3) resin content of the board; and the strength and dimensional stability of flake boards made from hardwoods. This study should reveal whether the specific gravity of the wood used in particle board has a significant effect on the strength of the derived board when interrelated with the factors of board specific gravity and resin or glue content. If the specific gravity of the wood causes significant variations in the strength of the resulting panels, then it should be possible in the future to predict more reliably the relative mechanical properties of boards made from woods of different specific gravities, with different board specific gravities.

Part of the work for this study was carried out by the author as an employe of the U. S. Forest Products Laboratory. The problem was carried on as an approved Forest Products Laboratory project.

Materials and Methods

Selection of Variables: Wood material requirements for the study dictated the choice of two species of widely different specific gravity. It was desirable that the species have similar structures. Aspen, *Populus tremuloides,* and yellow birch, *Betula alleghanensis,* were selected.

The board densities or specific gravities to be used were selected as representative of typical boards produced by the particle board industry. The densities and specific gravities used were 35 pounds per cubic foot and 0.56, and 45 pounds per cubic foot and 0.72. These specific gravities were based on ovendry weight and volume at equilibrium in constant conditions of 75°F. and 65 per cent relative humidity.

Four per cent resin solids and eight per cent resin solids, based on the weight of ovendry wood, were selected as this third variable. In this case, an attempt was made to bracket the percentages used by industry.

To obtain a measure of the variation to be encountered, several preliminary replications were fabricated. A series of static bending tests were run for each of these replications, and a statistical analysis of variance was run for the maximum load in static bending. There was no significant difference for this maximum load between the replications, at either the 5 per cent or the 1 per cent level. From this analysis it was assumed that reliably uniform replications could be fabricated. The relationship of variables and replications in the experimental design for this study is indicated in Table 1.

Material Procurement: Approximately 20 cubic feet of each species, in the green condition, were required. One yellow birch log provided a sufficient volume of material. Its average specific gravity, based on green volume and ovendry weight, was 0.65. Procurement of suitable aspen was more difficult. Three aspen logs were selected as matched material on the basis of specific gravity. The average specific gravity of each log was 0.36, 0.37, and 0.37. From this point on, the term wood specific gravity will replace the term wood species. There are other variations between species, but for this study they have been considered negligible.

Particle Production: In any kind of scientific study of strength properties, it is desirable to obtain uniformity in the material being tested. Consequently it is essential that the particles used for a study of this type have some uniformity. At the present time, the most easily produced uniform wood particle is the flake. A flake 1 inch along the grain, 0.5 inch across the grain, and 0.010 inch thick was produced on the disc flake cutter at the Forest Products Laboratory. The grain in the flakes, with respect to radial or tangential dimensions, was not controlled. Some difficulty was experienced in drying the flakes because they had a tendency to stick together. Drying was successfully carried out in a rotary drum, through which hot air was forced.

Resin Binder Application: Borden's WW–17 Urea Formaldehyde was used as a binder because it is a typical synthetic resin used in the particle board industry. This resin had a solids content of 65 per cent, and was applied to the flakes in the form of a mist or fine spray. The flakes were placed in a rotary drum. As the drum rotated, the flakes tumbled and the resin was applied through a paint sprayer at 45 pounds per square inch air pressure.

A technique was used by the author for photographing individual flakes after they had been resin-coated. A yellow fluorescent dye was added to the resin in very minute quantities. The resin was then sprayed on the flakes in the usual manner, and a 1-quart sample of flakes was selected from several places in the mixing drum. This large sample was spread out under an ultraviolet floodlight, where the presence of glue was evidenced by yellow spots on the deep purple background of wood. From this sample, 15 flakes were selected that represented the range from most glue present on a flake to least glue present on a flake. These 15 flakes were arranged in descending order from most to least glue present. Two ultraviolet floodlamps were used to illuminate these flakes, and the representative sample was then photographed in black and white. The flakes were turned over in place and photographed again so that both sides of each flake could be seen. The resin present on each flake was evidenced by white areas or spots on the flakes in the photographs. The uniformity of spread obtained was considered adequate.

In the flake-drying process, the moisture content was held to 6 per cent ± 1 per cent. The urea formaldehyde was not diluted with water. It required from 5 to 8 minutes to apply the resin to the flakes, and the moisture content of the resin-coated flakes was 10 per cent ± 1 per cent. These moisture contents were recommended as typical of industrial practice.

Particle Board Fabrication: The boards were pressed in rough form, 24 inches by 24 inches by ½ inch. This was the size from which the static bending and the dimensional stability specimens could be cut most conveniently. One-half-inch steel stops were

Table 1.—DESIGN OF EXPERIMENT

Species	Aspen				Yellow birch			
Resin content	4 per cent	resin	8 per cent	resin	4 per cent	resin	8 per cent	resin
Board specific gravity	0.561	0.721	0.561	0.721	0.561	0.721	0.561	0.72
Replications	3	3	3	3	3	3	3	3

Table 2.—SUMMARY OF AVERAGE STRENGTH AND DIMENSIONAL STABILITY VALUES

Board type	Moisture content Per cent	Specific gravity[1]	Modulus of rupture Psi	Proportional limit stress Psi	E Psi	Work to maximum load In.-lb. per in.[3]	Tension perpendicular surface Psi	Change thickness[2] Per cent	Change length[2] Per cent
Aspen									
4 per cent resin, 35 pcf.	6.8	0.56	4,760	1,930	788,000	2.28	44.4	10.1	0.11
8 per cent resin, 35 pcf.	6.6	.56	5,370	2,390	765,000	2.71	129.7	7.8	.12
4 per cent resin, 45 pcf.	6.5	.72	6,150	2,920	993,500	3.00	49.5	9.1	.12
8 per cent resin, 45 pcf.	6.6	.73	7,850	2,770	1,057,000	4.01	156.5	7.5	.12
Yellow Birch									
4 per cent resin, 35 pcf.	7.6	.56	1,940	1,220	579,000	.70	16.2	8.4	.17
8 per cent resin, 35 pcf.	7.5	.57	2,370	1,390	635,500	.91	38.5	7.6	.16
4 per cent resin, 45 pcf.	7.3	.72	4,510	2,200	868,500	1.74	43.4	10.8	.16
8 per cent resin, 45 pcf.	7.4	.73	5,960	2,810	955,000	2.67	131.4	8.0	.16

[1]Specific gravity of board based on ovendry weight and volume at equalibrium in constant conditions of 75°F. and 65 per cent relative humidity.
[2]After 1 month exposure at 80°F. and 80 per cent RH, after prior conditioning at 80°F. and 30 per cent RH.

placed between the 1/4-inch aluminum auls to control the thickness of the board.

The specific gravity of the board was predetermined by placing a weighed quantity of resin-coated flakes into the forming box. The weighed charge of flakes was laid down in a mat inside the forming box by distributing them evenly over a screen, which was vibrated by hand. The screen had 1-inch-square mesh. The forming box was set directly on the bottom caul. The forming box was then lifted free of the mat, the steel stops were placed on each side, and an identification tag was placed on the surface of the mat. After placement of the top caul, the assembly was slid into the press. The press was closed immediately, and pressure up to 750 psi, was applied to bring the upper caul down to the steel stops as rapidly as possible. Rapid closure was desired to avoid the possibility of precure in the glue lines. The press cycle, including closing time (40 seconds), was 15 minutes at 325°F. The finished board, as it came from the press, had a moisture content of about 2.5 per cent. The boards were allowed to cool, and then they were trimmed and cut into the required test specimens.

Four samples from each board fabricated were weighed and measured to determine whether the board actually was of the desired specific gravity. In two cases, boards were detected did not meet the requirements, and replacements were made. All the preceding fabrication work was carried out at the U. S. Forest Products Laboratory.

Testing Procedure: The static bending test and the tension test perpendicular to the surface were carried out according to the accepted tentative standards (1). The static bending test specimens were 3 inches in width and 14 inches long. These specimens were simply supported at the two ends with a span of 12 inches and with single point loading at the center of the span. The supports and loading block were shaped to a 3/4 inch radius of curvature. The rate of loading was 0.24 inch per minute. The load versus deflection curves were recorded automatically by the testing machine. The tension perpendicular to the surface test specimens were 2 inches by 2 inches. These blocks were glued between wood holding blocks, and the loading rate was 0.04 inch per minute. The specimens for these tests were stored at constant relative humidity conditions for a period of 1 month prior to testing.

The average moisture content of the conditioned boards was 6.6 per cent for aspen, while that for the yellow birch was 7.4 per cent at the time of testing. The percentage resin content of the boards appeared to have little or no effect on these moisture contents. It is known that the strength of the wood varies with the moisture content. The slight difference in the moisture content undoubtedly makes some difference in the strength values determined, and acts as another variable. Since the moisture content difference is less than 1 per cent, it will be assumed that this variable is negligible.

The test specimens were brought to equilibrium and tested at Michigan State University. A Baldwin Emery Testing Machine was used. There were four replications of each of the aforementioned tests within each board replication.

Dimensional stability was measured by determining the per cent change in length and thickness. The test specimens were first brought to equilibrium by placing them in a controlled room at 80°F. and 30 per cent relative humidity for 1 month. An 18-inch length was measured to the nearest 0.001 inch, and the thickness was measured to the nearest 0.001 inch. The test specimens were then placed in another controlled room at 80°F. and 80 per cent relative humidity for 1 month. At the end of this period, the specimens were again measured and the per cent change, based on the dimension at the first measurement, was calculated. There were two test specimens taken from each board. The dimensional stability measurements were made at the U. S. Forest Products Laboratory.

Results

Data Discussion: Table 2 contains average strength and dimensional stability values. Table 3 presents a summary of the statistical analyses. The change in thickness was considerable compared to the change in length. The change for thickness ranged from 6 to 11 per cent, while the change in length was consistently below 0.2 per cent.

The average property values for each board type were plotted in graphic form. A visual inspection of the graphic results suggests certain relationships. For the five strength properties tested, it appeared that boards made with aspen, the wood of low specific gravity, had consistently higher strength values. For the per cent change in length graphs, it appeared that aspen had a smaller dimensional change. The graph for the per cent change in thickness showed no apparent relationships. A comparison of the per cent change in strength properties between boards of different specific gravity indicates another relationship, which bears out Klauditz's work. That is, as the board density is increased, the strength properties of boards made with woods of different specific gravity have a tendency to equalize. In other words, at some high board density, the modulus of rupture for boards made of woods of varying specific gravity will be equal or nearly so.

Statistical Analysis: Duncan's text on Quality Control and Industrial Statistics (3) was closely followed in the selection of the proper error mean squares to be used for testing each variable.

An anaylsis of variance was performed to determine whether there were any boards in the 0.56 specific gravity class with significantly different specific gravities. A similar analysis was performed for the 0.72 specific gravity class. There was no significant difference within the specific gravity classes.

After the strength and dimensional properties of the boards were cal-

Table 3.—SUMMARY OF STATISTICAL ANALYSIS, INDICATING VARIABLES FOR WHICH SIGNIFICANCE WAS OBSERVED

Properties	Independent variables[1]			First-order interactions[1]			Second-order interactions[1]
	WS	R	BS	WS x R	WS x BS	R x BS	R x WS x BS
Modulus of rupture	----	----	----	----	**	**	----
Proportional limit stress	----	----	----	----	**	----	**
Modulus of elasticity	**	----	**	----	----	----	----
Work to maximum load	**	----	----	----	----	*	----
Tension perpendicular to surface	----	----	----	*	**	**	----
Per cent change in thickness	----	**	----	----	*	----	----
Per cent change in length	**	----	----	----	----	----	----

[1]WS stands for wood specific gravity; R stands for resin content; BS stands for board specific gravity.
*Indicates significance at the 5 per cent level.
**Indicates significance at the 1 per cent level.

culated, an analysis of variance for the three variables was performed. From the analysis of variance, and F test was made. A summary of the results of these seven analyses is given in Table 3.

The statitical analyses showed that the specific gravity of the wood used in fabricating the particle boards influenced the modulus of elasticity, the work to maximum load, and the per cent change in length. In these three cases, the wood with the lower specific gravity showed a higher value for each property.

Each of the independent variables in tension perpendicular to the surface shows bias when tested with the error mean square. However, none of the three values can be shown to contain bias independent of the interactions, all of which are significant.

The statistical analysis showed that the amount of resin used in fabricating the boards influenced the per cent change in thickness. Eight per cent resin solids resulted in reduced thickness change over the 4 per cent resin level.

The statistical analysis showed that the specific gravity of the boards influenced the modulus of elasticity. Boards of high specific gravity had higher modulus of elasticity values than did boards of low specific gravity.

The statistical analyses do not consistently substantiate the apparent relationships as indicated by the graphs of the actual strength values. There may be supporting significant differences that are not shown in the analyses of variance. There are two possible reasons why these differences do not appear. One is that interactions are so large, and the other is that there are so few degrees of freedom in the analyses.

Discussion

The hand felting methods used in fabricating the particle boards for this study are a subject of controversy. It is felt by some men in the field that, without complete automation in the felting process, a uniform board cannot be fabricated. All that can be done in any type of felting procedure is to distribute a uniform layer of uncompacted particles on the caul. The forming box used in this work was merely a boundary to define the over-all dimensions of the pressed panels.

In an automatic felting system, the particles are distributed on a moving conveyor by any of a number of feed mechanisms. The only difficulties encountered in the hand felting system used here was that groups of flakes tended to stick together for board types that had heavy resin coverage per flake. These groups were broken up partially by hand and again by the vibrating screen over the forming box, so that, in general, single flakes fell onto the mat. The forming box had a series of horizontal lines 1 inch apart on the inside walls. Low areas were built up progressively by sifting more flakes over these areas than over the higher areas. In no cases were high areas compacted to produce a uniform height of mat.

The boards made from wood of high specific gravity and at low board specific gravities did show areas of low density and of high density on the cross section.

Conclusion

It may seem strange that a wood of low strength properties (aspen) should produce a particle board with higher strength properties than another board made with a wood of high strength. The answer lies in the specific gravity of the wood and the requirements for a good glue bond. A given weight of flakes of a low specific gravity wood occupies a greater volume than the same weight of similar flakes of a wood of high specific gravity. When these volumes of wood are compressed to the dimensions of a board, a higher relative contact will occur for the greater volume of wood, and a better glue bond between flakes results.

There is a greater glue spread per unit of particle surface for the birch flakes as compared to the aspen flakes, but the higher relative contact of the aspen flakes still controls strength properties for medium-density particle boards. For high-density particle boards, the glue spread per unit area of particle surface would become the controlling factor.

The scope of this problem is no large, and consequently the results of the work cannot be reliably applied over a wide range of wood species Density of woods rather than species should be used as the basis for comparison. The results should prove reliable for medium-density particle boards made with hardwoods.

In general, the use of high-density hardwoods for the manufacture of particle boards in the medium-density range should be discouraged.

Aspen is one of the hardwoods that will produce excellent flakeboard.

Further basic research along these lines should improve our ability to predict properties for the boards made with known variables.

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A Notched Cleavage Specimen for Evaluating Strength of Glue Joints[1]

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A new method of testing glue joints in edge-glued panels has been developed and evaluated. The strain distribution in the proposed specimen is related to actual strains in edge-glued panels in service due to humidity changes. The test procedure was evaluated in a long-term program designed to point out important variables that affect test results.

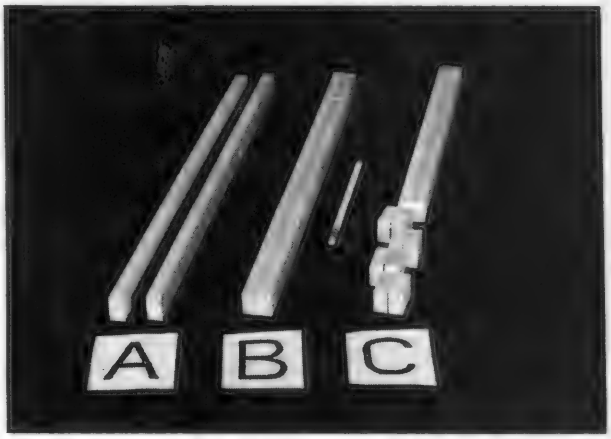


Fig. 1.—Preparing the test specimens: A assembly ready for gluing; B glued assembly; C assembly from which four specimens have been prepared.

THE PAST TEN YEARS have seen a rapid increase in the production of edge-glued lumber panels in the United States. The increase in production of this type of lumber product has received its greatest impetus in our Western and Southern lumber producing areas, where at present both select and common lumber are being formed into panels by edge-gluing for various purposes other than as core stock for furniture. This trend has more than offset the decrease in the production of edge-glued lumber cores for furniture panels due to the competition of particle board.

It follows that, as our lumber industry progresses further into a second growth economy, more and more edge-gluing of lumber will take place in order to provide suitable products and still maintain proper utilization of our lower grade timber.

As is the case with other glued wood products, the producers of edge-glued lumber panels have realized the importance of maintaining a constant check on the quality of the glue lines in their product. From this realization, control tests have evolved that are designed to eliminate defective products. One of the most common tests performed is the chisel test, which consists of notching the end of the panel at the glue line with a band saw, and then splitting the panel with a wedge; the split panel is then observed for glue-line failure. At times, the notching is eliminated as a step in this procedure for expediency.

Another method commonly used to screen out defective panels is to flex the panel in order to stress the joints, and thus expose joints that are inadequately bonded. From the standpoint of obtaining quantitative data for the comparison of glued joints, both methods are entirely inadequate. To the dismay of producers of edge-glued panels, numerous field failures have been traced to improper bonding, which could have been detected by an adequate testing program.

There are several types of tests that could be used to evaluate edge-glued joints. A modified block-shear test specimen has been used for this purpose. The specimen has the same dimensions as the standard block-shear specimen (ASTM Designation D 805–52) except for width, which is limited by the thickness of the product. The standard width is two inches in a direction parallel to the glue line and across the grain of the specimen. Specimens prepared from edge-glued panels are limited in width to the thickness of the panel, or 5/8 to 1¼ inches in normal constructions.

Two other standard test specimens have been modified for testing edge-glued panels—the tension-perpendicular-to-the-grain specimen and the cleavage test specimen, both described in ASTM Designation D 143–52. Although these tests have been designed for testing solid wood, they have been modified to include a glue line in the area of principal stress. These specimens, if used for edge-glued panels, would also be narrower than standard specimens, being limited

[1] A contributed paper, received June, 1958.

The Authors: John Yavorsky holds BS, MS, and PhD degrees from the State Univ. College of Forestry at Syracuse. Before accepting his present position, he was on the research staff at Syracuse.

John Brown received BS and MS degrees from Michigan State University, and is a candidate for the PhD at Syracuse. Before coming to Syracuse, he was employed in the Research Dep't, Potlatch Forests, Inc.

WHAT THIS RESEARCH MEANS

Many of our wood-using industries are advancing rapidly into a "panelized" economy as our supplies of large size, clear lumber diminish. New glues and gluing techniques have made this possible. Testing methods for the resulting edge-glued joints, however, have remained cumbersome or qualitative only, and should be improved.

This paper analyzes the stresses that cause failure in edge-glued lumber joints, and proposes a new type of test specimen and testing technique for evaluating such joints. The resulting test procedure provides a quantitative method that is rapid, extremely simple, and accurate—qualities that should make the technique useful in research, adhesive screening, and quality control in production.

At present, work is progressing to modify the testing technique for testing internal bond strength in platen-pressed particle board.

Editor

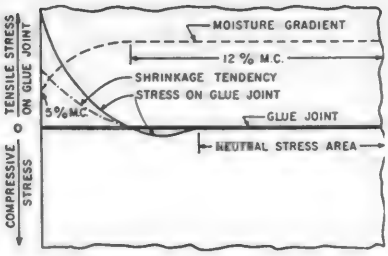
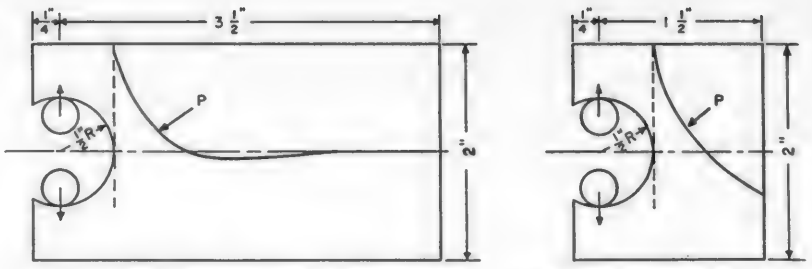


Fig. 2.—Theoretical distribution of stresses imposed on a glue line near the end of an edge-glued panel due to a moisture gradient (12).



a. STANDARD CLEAVAGE SPECIMEN. b. MODIFIED CLEAVAGE SPECIMEN

Fig. 3.—Stress distribution along the central axes of Xylonite models of cleavage specimens. P = major principal stress. (From Coker and Coleman (4)).

in this direction by the thickness of the panel.

Any of these specimens in its modified form, and possibly other modified standard specimens, could be used to evaluate glue lines in edge-glued panels. The objections to these tests in any large testing program or quality control work are in two general categories: 1) the specimens are difficult to prepare, and their preparation is time consuming; and 2) expensive equipment, generally a universal testing machine, is required for testing. As a result of these objections, most producers of edge-glued lumber panels have relied almost entirely on the chisel and flexing tests previously described.

Nature of Stresses in Edge-Glued Panels

The stresses imposed on the glue lines of an edge-glued panel in service, by changes in moisture content, are approximated in Fig. 2. The assumption is made that the panel has previously acquired an emc (equilibrium moisture content) of 12 per cent, and is now in an atmosphere where the emc is 5 per cent. The rapid drying at the end of the board produces a moisture gradient in the panel as shown in the figure. As a result of this moisture gradient, a shrinkage tendency gradient is also set up. This tendency to shrink is greatest at the very end of the panel, and decreases with distance from the end. The end of the panel is restricted from shrinking by the interior of the panel, which is still at a higher moisture content. The resulting stresses are diagramed in Fig. 2, which shows a high tensile stress at the end of the panel that diminishes with distance from the end until an area is reached where the stress crosses over into a compressive stress. This compressive stress in turn diminishes until an area of neutral stress is reached in the region where no shrinkage has occurred.

This theoretical description does not take into account the loss of moisture from the faces of the panel. However, because moisture moves from the end of the panel 10 to 15 times faster than from the faces, the phenomenon described by Fig. 2 is assumed to be a valid approximation. It can further be surmised that similar stresses occur at the glue lines at the face surface of the panel due to the moisture gradient established through the thickness of the board.

With a change from a low emc to a higher emc, the reverse would occur with compressive stresses formed at the edge of the panel. These compressive stresses would diminish with distance from the end of the panel, and eventually pass over into an area of tensile stress. The area of neutral stress would again be reached further into the panel.

It is evident from the above description of stresses present in edge-glued panels, due to changing service conditions, that a cleavage-type stress is present. Cleavage in wood has been defined as "the resistance wood offers to splitting. It involves tension perpendicular to the grain but differs from this in one fundamental respect; the acting force is the prying effect of a wedge or its equivalent." (3)[2]

Coker and Coleman (4) have investigated the stress pattern in a Xylonite model of a standard cleavage specimen by photoelastic methods. Fig. 3a shows the results of this analysis. The stress pattern in this Xylonite model bears a close resemblance to the theoretical stress pattern heretofore described for edge-glued panels. By successively shortening the test specimen, they obtained the stress pattern shown in Fig. 3b, which consisted of a maximum tensile stress at the edge of the hole, a crossover into compressive stress midpoint between the edge of the hole and the end of the specimen, and a compressive stress increasing from that point to the end of the specimen. Coker and Coleman concluded that, in this final specimen form, maximum tensile stress was imposed upon the central axis of the specimen, which insured that failure would take place along this central axis, unless anisotropy of the wood was unfavorable.

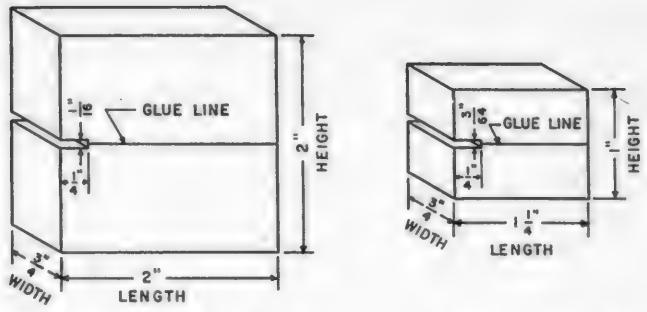
The specimen geometry shown in Fig. 3b was adopted by Yavorsky (12) for the analysis of stress and strain in a wood cleavage specimen for testing glue joints in wood. This investigation, which employed electrical strain gauges and mechanical extensiometers for strain measurements, and the brittle lacquer technique (13) to obtain a "picture" of the resulting stresses, verified the predictions of Coker and Coleman as to stress pattern, location, and direction of the principal stress in a wood cleavage specimen.

The Notched Cleavage Specimen

The notched cleavage specimen has been in a process of continual development at Syracuse since 1951. The original dimensions of the specimen are shown in Fig. 4a. The specimen was used in this form by Currier (5) in an investigation to determine whether correlation existed between this test method and the standard block-shear test. For this initial work, a cleavage tester adapted from Lacey and Howe (8) was used as the testing machine. This tester will be described in more detail in the next section of this paper. Currier's work showed a significant positive correlation between cleavage breaking load and compression shear strength for standard block-shear specimens of ponderosa pine (*Pinus ponderosa,* Laws) and yellow poplar (*Liriodendron tulipifera,* L.).

Subsequent research has brought the specimen to its present form as shown in Fig. 4b. Shortening the specimen from 2 inches to 1¼ inches increased strain at the notch for a given load. This indicates an increased tensile stress perpendicular to the glue line, which is necessary for cleavage action. Reducing the height of the specimen from 2 inches to 1 inch did not reduce the strength of the specimen significantly. A ¾ inch width was adopted as standard, because most edge-glued panels are of this thickness or thicker. Reduction of the specimen to these dimensions, while providing the same information ultimately as the larger specimen, is much less wasteful of material. The dimensions of the specimen presently in use are ¾ inch wide,

[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.



a. ORIGINAL FORM. b. PRESENT FORM.

Fig. 4.—The notched cleavage specimen.

1 inch high, by 1¼ inches long, with a notch 3/64 inch wide and ¼ inch deep centered on the end of the specimen across the ¾ inch width.

The specimen shown in Fig. 4b has been analyzed for strain patterns by the use of electrical strain gauges and the brittle lacquer technique. Fig. 5 illustrates the strains occurring in a sugar maple (*Acer saccharum*, Marsh.) specimen when a 30-degree wedge is forced into the notch with a force of 88.5 pounds. For this investigation, SR-4 A7 electrical strain gauges were cemented to the specimen at the three gauge points indicated in Fig. 5. The strains at the three gauge points in micro-inches per inch are plotted in Fig. 5, and an approximate curve is drawn through the points to indicate the strain pattern. From this curve it is evident that the strain follows a pattern such as would be predicted from the photoelastic stress analysis of a cleavage specimen by Coker and Coleman as previously described (4).

Fig. 6 is a sketch of a specimen coated with brittle lacquer after being stressed to cause a strain crack pattern in the coating. The principal strains and, therefore, the principal stresses are perpendicular to the cracks in the coating (13). It can readily be seen that the principal stress at the bottom of the notch is normal to the glue line because of the parallelism of the cracks in this location to the plane of the glue line.

The crack pattern in the coating also gives a qualitative "picture" of stress concentration. Where the cracks are closest together, areas of concentrated stresses exist (13). From Fig. 6 it is evident that stress concentrations exist at the bottom of the notch. However, these stresses are essentially normal to the glue line in the vicinity of the glue line, and are the types of stresses desired in a cleavage specimen. There is a possibility that stress concentrations exist at the very corners of the notch, but stress coat techniques failed to differentiate between stresses in these areas along the bottom of the notch. If such stresses do exist, they will initiate failure in the notch corners when the glue joint is as strong as the wood. There is some evidence that this situation exists from examining broken specimens. Such stress concentrations exist in most of the standard test specimens for glue line evaluation (14). This fact will not detract from their utility if the results of these stress concentrations are thoroughly understood.

From the foregoing description of the specimen, several favorable attributes of the specimen may be summarized:

1. Stresses are produced in the specimen similar to those which occur in edge-glued construction as the wood undergoes changes in moisture content in service.
2. The specimen is easily prepared with common woodworking equipment. The specimen could be prepared with only a table saw, but a band saw or jig saw facilitates cutting the groove. A small jointer or planer is also convenient to reduce test material to the proper thickness.
3. The small size of the specimen permits more test specimens to be prepared from a given amount of material. In studies to evaluate adhesives or other test variables, the variability of the wood can be kept to a minimum by the close spacing of the test specimen.

Other advantages of the test specimen will be apparent as significant variables are examined later in this report.

The Testing Tool

The basic design of the testing apparatus used for applying the load to the specimen was developed at the Forest Products Research Laboratory in England by P. M. C. Lacy and H. A. Howe (8). The apparatus was used by these investigators as a mechanical means of splitting a specially designed glued cleavage specimen employed in their investigation of bond strength in wood.

The testing apparatus as modified for use with the notched cleavage specimen is shown in Fig. 7. It consists of

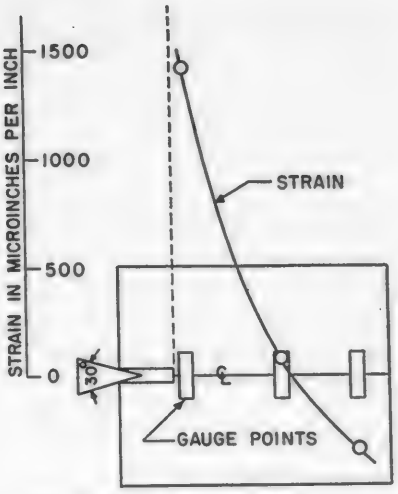


Fig. 5.—Strain distribution in the notched cleavage specimen as indicated by SR-4 A7 electrical strain gauges. Force on wedge = 88.5 pounds.

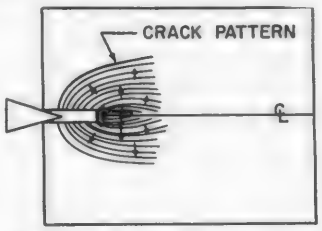


Fig. 6.—Typical stress pattern in the notched cleavage specimen as indicated by the brittle lacquer technique. Direction of stress is perpendicular to the cracks as shown by arrows.

a 12-inch C-clamp rigidly mounted on a ½-inch steel plate. The screw of the C-clamp is kept in alignment by the two adjustable pillow blocks, and is driven by means of a heavy iron wheel mounted on the end. The other end of the screw contacts the ram of a compressometer, which in turn transmits the load to the end of the specimen opposite the notch. This load forces the 30-degree wedge, mounted horizontally on the end of the C-clamp, into the notch of the specimen, thus creating the desired cleavage action. The oil reservoir in the block of the compressometer behind the ram is connected to a threaded hole in the top of the block by a 1/16-inch hole. The oil pressure is thereby transmitted through the pulsation damper screwed into the top of the block to a maximum-reading hydraulic pressure gauge. Number 10 motor oil is suitable for the hydraulic fluid.

The compressometer is free to move in the greased slideway formed by the steel base plate and the two angle irons mounted on the base plate. Except where otherwise indicated in this report, the ram area is 1.77 square inches. To obtain true breaking load of a specimen, the gauge pressure is multiplied by 1.77. For instance, where

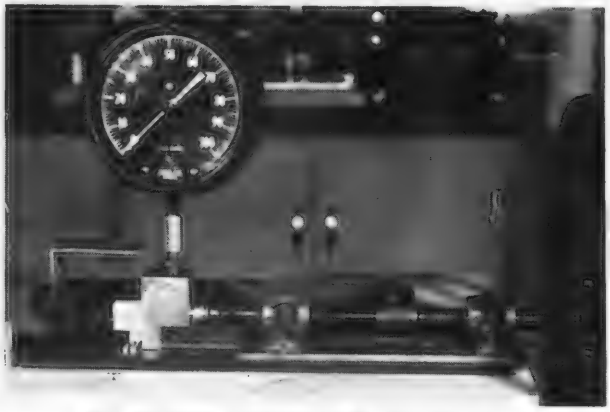


Fig. 7.—Testing apparatus with notched cleavage specimen in position for testing.

Table 2.—EFFECT OF MOISTURE CONTENT AND END-GRAIN CONFIGURATION ON THE BREAKING LOAD FOR SOLID HARD MAPLE NOTCHED CLEAVAGE SPECIMENS

Slope of growth rings	Per cent moisture content						
	Oven dry	4	8	12	18	Saturated[1]	Average
0°-15°	60[2]	60	61	71	92	72	69
16°-30°	74	84	89	94	86	86	85
31°-45°	63	78	81	106	97	88	85
46°-60°	81	86	123	127	135	114	111
61°-75°	102	104	134	152	131	118	124
76°-90°	99	102	120	142	136	125	121
Average	80	86	101	115	113	100	99

[1]Thoroughly saturated by soaking in water.

[2]Mean gauge pressure in psi at breaking load for 5 specimens in each cell of table. Ram area 1.77 sq. in.

it was previously mentioned that a load of 88.5 pounds was applied to the specimen analyzed for strain by means of electrical strain gauges, the load was calculated by multiplying a gauge pressure reading of 50 psi by 1.77 sq. in. to obtain 88.5 pounds.

Modifications to the original machine as designed by Lacey and Howe include: 1) the adjustable pillow blocks to assure a straight-line application of force from the C-clamp screw through the test specimen to the chisel point, 2) the pulsation damper to prevent gauge damage from needle snapback when high breaking loads are encountered, 3) the horizontally positioned chisel edge, which allows less variation in applied force and facilitates indexing of the test specimen (the original machine had a vertically positioned chisel edge), 4) an index guide to position the specimen laterally in the machine, and 5) a swiveled safety cover that swings over the specimen to prevent injury to the operator from an occasional flying half specimen.

The load is uniformly applied to the test piece by timing the increase in load on the hydraulic gauge. For the experimental work subsequently described in this report, a gauge load increase of 10 pounds per second was used, which equals 10 x 60 x 1.77 or 1,060 pounds per minute on the specimen. It has been found that the operator can evenly apply this load by a counting procedure.

Table 1.—EFFECT OF GREASING THE WEDGE ON THE BREAKING LOAD OF SOLID HARD MAPLE NOTCHED CLEAVAGE SPECIMENS. WEDGE ANGLE OF 30 DEGREES

Specimen No.	Wedge not greased	Wedge greased
1	100[1]	60
2	110	64
3	94	76
4	122	76
5	140	72
6	148	72
7	120	80
8	136	70
9	170	62
10	112	74
Mean	125	71
Standard deviation	23.4	6.6
Coefficient of variation	18.7	9.3

[1]Gauge pressure at breaking load in psi. Ram area 1.7 7sq. in.

The testing apparatus has several advantages when compared with conventional testing machines:

1. The speed with which a test may be performed is greatly accelerated. An experienced operator can place the specimen in the machine, test the specimen, estimate wood failure, and record the breaking load and wood failure in approximately 30 seconds.

2. The machine is relatively inexpensive. It is estimated that a machine shop could fabricate the machine for $100 to $150.

3. The machine is extremely simple to operate and maintain. Frequent calibration of the hydraulic gauge and replenishment of oil in the system are the primary maintenance problems.

Variables That Affect Test Results

To analyze the results of any testing procedure intelligently, a thorough knowledge must be had of the variables that affect the results. A series of tests have been performed on the notched cleavage specimen to evaluate the important variables. These variables may be broken down into two main categories: 1) those inherent in the test specimen, and 2) those inherent in the testing apparatus.

Reducing Variability in the Testing Apparatus: Several studies have been made to reduce variability in the testing apparatus to a minimum. Some of these studies have resulted in slight modifications in the apparatus or in testing procedures.

Misalignment of specimen in tester: Tests have shown that the variation in the breaking load for the specimen is reduced when the center line of the specimen is a continuation of the center line through the C-clamp screw, compressometer, and wedge. An electrical strain gauge analysis showed that, whenever the specimen was moved to one side or the other of this center line, the strain at the notch changed significantly. As mentioned previously, the C-clamp screw and compressometer are kept in alignment by the pillow blocks and angle iron slideway, respectively. An aluminum indexing guide has been added to allow for uniform lateral positioning of the test specimen. Best results have been obtained when this indexing guide is set so as to position the center line of the specimen on the center line through the C-clamp screw and compressometer.

Lubrication of wedge: Keylwerth (6), by vector analysis of the splitting action of a wedge, has determined that the coefficient of friction between the wedge material and the material being split is important in resolving the component of force normal to the plane in which the split occurs. As the coefficient of friction increases, the component of the splitting force normal to the plane of splitting decreases. Applying this information to the notched cleavage specimen, the breaking load of the specimen should increase with an increase in the coefficient of friction between the steel wedge and the wood. This was confirmed by a series of experiments on solid and glued notched cleavage specimens. In one experiment, 20 solid maple specimens were randomly sorted into two groups of ten. One group was tested with a clean, 30-degree wedge. The other group was tested by the same wedge lightly greased with a medium cup grease before each test. The results of this experiment are given in Table 1. In this limited experiment, the average gauge-pressure breaking load of the specimen was reduced 43 per cent by the greased wedge; that is, from 125 pounds to 71 pounds. This experiment has since been repeated with similar results, which indicate that Keylwerth's analysis is applicable to the notched cleavage specimen.

Northcott (10), in developing a "glueline-cleavage test" for plywood

adhesives, found that it was necessary to grease the wedge used to test specimens in order to keep the wedge surface free of pitch present in Douglas-fir specimens, and thus reduce variation in friction. His study showed that the coefficient of variation for his test specimen was reduced from 13.4 to 9.6 by this procedure. In Table 1 it is shown that the coefficient of variation for the notched cleavage specimen was also reduced, from 18.7 to 9.3, by greasing the wedge. Subsequent studies have confirmed this trend.

As little information is available on the coefficient of friction of various woods, it seemed desirable to limit this variable as much as possible by adopting the procedure of lightly greasing the wedge before each specimen is tested as standard practice. The resulting lowering of the coefficient of variation and the limiting of the coefficient of friction variable indicates that higher confidence may be placed in test results when this procedure is followed, or that fewer specimens are necessary for the same confidence level.

Wedge angle: Keylwerth's analysis of the splitting action of a wedge also indicated that the tensile component of the splitting force perpendicular to the plane of splitting is dependent on the wedge angle—the smaller the wedge angle the larger the perpendicular force component (6). Applying this information to the notched cleavage specimen, as the wedge angle is decreased, the resultant force perpendicular to the glue joint increases. Thus failure will result at a lower load, and a more valid estimate of the glue joint strength is obtained.

It was also considered desirable to have this normal force as high as possible in relation to the total force so as to more nearly simulate the cleavage failure in the presently accepted cleavage specimen as described in ASTM Designation D 143–52. On the other hand, the wedge angle must be kept large enough so that the wedge will not contact the bottom of the notch before failure occurs. This bottoming of the wedge produces erratic results. After these things were taken into consideration, a 30-degree wedge was selected for use with hard maple specimens that had a 1/16th-inch notch width. Trials on hard maple specimens with 30 and 60 degree wedges resulted in breaking loads for the 30-degree wedge that were less than half as great as those required for the 60-degree wedge. These trials also showed that the coefficient of variation was reduced when the smaller wedge angle was used.

Conversely, a comparison of the 60- and 30-degree wedges on glued specimens of ponderosa pine indicated that the coefficient of variation for the two wedges did not differ significantly. It was also found in this study that the 30-degree wedge occasionally bottomed in the 1/16-in-wide notch because of compression of the wood at the wedge contact point. On the species of lower specific gravity it is necessary, therefore, to use a larger wedge angle, reduce the width of the notch, or increase the depth of the notch in order to prevent bottoming of the wedge. Of the three remedies, reducing the notch width to 3/64 inch was selected as the best solution to the problem.

The 30-degree wedge and 3/64-inch notch width have been standardized so far. It would be desirable for all future users of this testing procedure to employ this standard wedge angle and notch width so that their results can be directly compared with results obtained elsewhere.

Variability in the Test Specimen: Several of the variables that affect the breaking load and wood failure for the notched cleavage specimen will be discussed in order to develop an understanding of some of the idiosyncracies of this testing method. It will be evident from the following discussion that the simplicity of the specimen facilitates comprehensive studies of the different variables that affect test results.

End-grain and face-grain configuration: End-grain slope is defined as the angle between a line perpendicular to the notch width and a line tangent to an annual ring. The point of tangency is at the edge of the notch. *Face-grain slope* is defined as the angle between the direction of grain and the center line of the specimen on the 1-inch-wide face. The direction of grain on this face of the specimen can be determined either by a scribing technique or an inking technique, both of which are described in U. S. Forest Products Lab. Report No. 1585 (7).

Fig. 8 shows several end- and face-grain configurations. The methods for measuring the grain angles are apparent in these drawings. The 0-degree end-grain specimen could be cut from an edge-glued panel consisting of flat sawn boards, and the 90-degree end-grain specimen from a vertical-grain panel. It is possible, of course, to have end-grain slopes between these extremes in all possible combinations in the glued notch cleavage specimen. The same holds true for face-grain slope. Face grain is termed *converging* if the grain slopes toward the glue line when the specimen is viewed from the notched end. The other face-grain configurations in Fig. 8 are apparent when related to this. Several studies have been made to determine the effects of these two variables. Three of these studies are presented in Tables 2, 3, and 4.

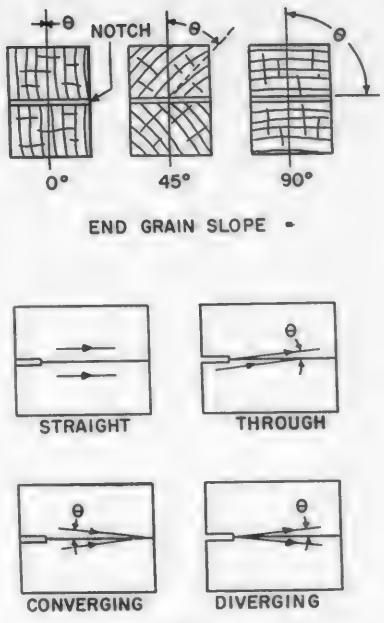


Fig. 8.—Face-grain and end-grain configurations for the notched cleavage specimen.

Table 2 indicates that, as the end-grain slope of glued hard maple specimens increases from 0 to 90 degrees, the breaking load also increases. The cleavage failure in this specimen is essentially a failure in tension perpendicular to the grain. Hard maple is considerably weaker in tension in the tangential direction than in the radial direction. The weak ray tissue forms a ready plane of failure when the wood is stressed in the tangential direction. As this is essentially the case in the 0 to 15 degree specimens, low breaking loads result. The rays in the 76 to 90 degree specimens, being essentially perpendicular to the plane of failure, do not have such an influencing effect. The result is a high average breaking load for these specimens. The relationship of breaking load to end grain is not a straight-line relationship, but rather approximates the Hankinson distribution (1).

Table 3a shows the results of a two-factor analysis of glued hard maple specimens with end grain as one factor and face grain the other factor. End grain was controlled between 0 and 5 degrees for the 0-degree end-grain specimens and between 40 and 50 degrees for the 45-degree end-grain specimens. An end-grain configuration of 90 degrees could not be included in this study because it failed to develop from the material available. Face-grain slopes were controlled within ± 2 degrees from the stated angles.

Table 3a.—EFFECT OF FACE-GRAIN AND END-GRAIN CONFIGURATION ON THE BREAKING LOAD OF GLUED HARD MAPLE NOTCHED CLEAVAGE SPECIMENS

End-grain configuration	Face-grain configuration: Straight	Converge 10°	Diverge 10°	Row average
0°	$\bar{x}$ =76.0[1] s = 9.15[2] V=12.0[3]	$\bar{x}$ =79.9 s =10.42 V=13.0	$\bar{x}$ =69.1 s = 6.18 V= 8.9	$\bar{x}$=75.0
45°	$\bar{x}$ =84.2 s =11.11 V=13.2	$\bar{x}$ =70.1 s =12.13 V=17.3	$\bar{x}$ =85.8 s = 8.30 V= 9.7	$\bar{x}$=80.0
Average	$\bar{x}$ =80.1	$\bar{x}$ =75.0	$\bar{x}$ =77.4	$\bar{x}$=77.5

[1]Mean gauge pressure in psi at breaking load for 30 specimens in each cell of table. Ram area 1.77 sq. in.

[2]s=standard deviation for the 30 samples in the cell.

[3]$V = \frac{s}{\bar{x}}$ (100) = coefficient of variation for the 30 samples in the cell.

Table 3b.—ANALYSIS OF VARIANCE FOR THE FACE-GRAIN —END-GRAIN EXPERIMENT

Source	Degrees of freedom	Sums of squares	Mean square	F-ratio
End grain (E)	1	1,145	1,145	13.63[2]
Face grain (F)	2	796	398	4.74[1]
Interaction (ExF)	2	7,437	3,718	44.3[2]
Error	174	14,599	84	------
Total	179	23,977	-----	------

[1]Significant at the 5 per cent level.
[2]Significant at the 1 per cent level.

Table 3c.—EFFECT OF FACE-GRAIN AND END-GRAIN CONFIGURATION ON THE PER CENT WOOD FAILURE FOR HARD MAPLE NOTCHED CLEAVAGE SPECIMENS

End-grain configuration	Face-grain configuration: Straight	Converge 10°	Diverge 10°	Average
0°	88[1]	14	100	67
45°	50	3	78	44
Average	69	8	89	55

[1]Per cent wood failure, mean of 30 samples.

The analysis of variance for these data (Table 3b) indicates that a significant interaction is present between end-grain and face-grain configurations. Fig. 9, a graphical presentation of this interaction, shows that, when the face grain is diverging 10 degrees, the 45-degree end-grain specimens show a greater breaking load than the 0-degree end-grain specimens. The reverse is true for the specimens with a converging 10-degree face-grain configuration. Since the specimens for converging and diverging grain were selected alternately from the same glued-up assemblies, this interaction is very likely a true presentation of this phenomenon. The reason for this intreaction is not immediately apparent, and would probably require a more rigorous stress analysis for its determination.

The main effects in the analysis of variance, end grain and face grain, both showed significant differences. When the entire experiment is taken into consideration, the 45-degree end-grain specimens had significantly higher breaking loads than the 0-degree end-grain specimens at the 1 per cent level of significance. A difference, significant at the 5 per cent level, is also present for the face-grain variable.

Table 4.—EFFECT OF END-GRAIN CONFIGURATION AND WEDGE ANGLE ON THE BREAKING LOAD FOR GLUED PONDEROSA PINE NOTCHED CLEAVAGE SPECIMENS

End-grain configuration	Wedge angle: 30°	60°
0°	$\bar{x}$ =36.1[1] s = 3.05[2] v = 8.5[3]	$\bar{x}$ = 93.2 s = 7.78 V= 8.3
90°	$\bar{x}$ =46.0 s = 7.28 V=15.8	$\bar{x}$ =101.9 s = 13.10 V= 12.9

[1]Mean gauge pressures in psi at breaking load for 24 specimens in each cell of table. Ram area 1.77 sq. in.

[2]s=standard deviation for the 24 samples in the cell.

[3]$V = \frac{s}{\bar{x}}$ (100) = coefficient of variation for the 24 samples in the cell.

This difference is apparently between straight-grain and converging-grain specimens.

The intermediate value for diverging-grain specimens is not significantly different from the other two face-grain configurations. In most studies where this specimen has been employed, an effort has been made to have the material as straight grained as possible. A randomization of the orientation of the blocks before the notches are cut then assures that the face-grain configuration variable will be randomized. It is considered more important, however, to control end-grain configuration within definite limits as determined by the type of study to be performed.

The average wood failure values for this experiment are shown in Table 3c. These data were not analyzed statistically, but certain trends are evident. First, for the end-grain configuration, as the slope increased the wood failure decreased. This has been demonstrated in more detail in other studies on hard maple glued specimens, which show a gradually decreasing wood failure as the end-grain slope increases. This would be expected from the data given in Table 2, which show an increasing breaking load with increased slope of end grain. As the strength of the wood increases, the glue line is more highly stressed, which causes failure in the glue line.

In considering face-grain configuration, it is evident that the converging grain forces failure into the glue line, which results in low wood failure. This type of failure exposes the glue line for inspection of gluing defects, and thereby makes this particular test specimen and procedure a useful tool for the evaluation of adhesives and other gluing variables that are reflected in the physical appearance of the glue line. It is not necessary to have the grain converging 10 degrees to achieve this effect. Specimens that converge 5 degrees have demonstrated the same tendencies.

In the diverging specimens, failure initiates at the notch and often follows the diverging grain, thereby resulting in high wood failure. Again, the randomization of the orientation of the slope of grain before the notches are cut is sufficient for most studies, unless it is particularly desirable to evaluate the physical appearance of the glue line. In this case, converging face-grain specimens should be used.

In referring to Tables 3a and 3c it should be noticed that, for each face-grain configuration, as the wood failure decreases with increasing end-grain slope, the coefficient of variation increases. In other words, variability in hard maple specimens is largest in relation to the mean breaking load value when the wood failure is lowest, which suggests that the variability in the glue line or glue line-wood interface is larger than the variability in the wood itself. The comparisons between converging and diverging grain directions most vividly point this out, since the two types of specimens were alternately selected from the same assemblies, the only difference being that one type was reversed end to end before the notch was cut.

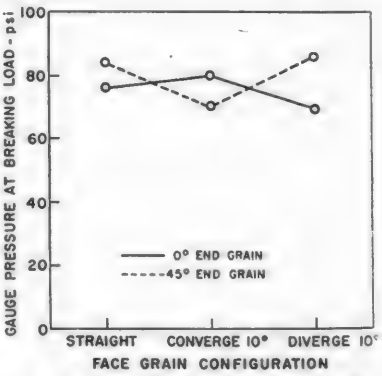


Fig. 9.—Interaction between face-grain and end-grain configurations. Each point represents the mean breaking load for 30 specimens. (See Table 3a for data)

Another study on ponderosa pine specimens is presented in Table 4. In this study, two different wedge angles were used to test specimens, with 0- and 90-degree end-grain slopes. For this species, it is again evident that the vertical-grain specimens (90-degree end-grain), have larger breaking loads than flat-grain specimens (0-degree end-grain). The difference between the two end-grain slopes was found to be significant at the 1 per cent level for each wedge angle by means of "t"-tests. The coefficient of variation for the 90-degree end-grain specimens is larger than for the 0-degree end-grain specimens. This trend is also present in the previously described experiment on hard maple glued specimens as indicated in Table 3a. In that study, the 45-degree end-grain specimens had higher coefficients of variation than the 0-degree specimens. This occurrence suggests the possibility of heterogeneous variance in extreme cases, a factor that should be carefully watched for if the data are to be analyzed statistically.

Moisture content: As is the case with other types of test specimens for wood, the moisture content of the notched cleavage specimen has an influencing effect on the breaking loads. The effect of moisture content on the breaking load for solid hard maple notched cleavage specimens is shown in Table 2. The average breaking load increases with an increase in moisture content up to about 12 per cent, then gradually declines up to the point of complete saturation. The results of this test follow a pattern similar to the results obtained by Bensend and Preston on standard birch plywood tension shear specimens (2). As indicated in Table 2, it is important to control the moisture content of the notched cleavage specimen in order to reduce this source of variability.

Specific gravity: Within a given species of wood, the breaking loads for vertical-grain specimens (90-degree end-grain) are proportional to the specific gravity of the wood. The breaking loads for flat-grain specimens (0-degree end-grain) are only slightly influenced by small changes in specific gravity within a given species. In the latter case, the weakness of the ray tissue is apparently the predominating factor and overshadows the influence of specific gravity. In the 90-degree end-grain specimens, the ray tissue is perpendicular to the plane of failure, which thus reduces its influence on breaking load.

Species effects: Although most of the experimental work with the notched cleavage specimen has utilized hard maple, limited studies have been made on other species often used in edge-glued panels. Table 5 shows average breaking loads obtained for several species. These are only approximate values for the species. Results obtained for any particular study would depend on the several variables outlined in this paper.

Table 5.—AVERAGE BREAKING LOADS FOR THE NOTCHED CLEAVAGE SPECIMEN FOR VARIOUS SPECIES

Species	Average breaking load[1]
Hard maple	80[2]
Red oak	70
Black cherry	65
Yellow poplar	45
Basswood	40
Ponderosa pine	45
Redwood	30

[1]These are approximate averages only.
[2]Mean gauge pressure in psi at breaking load. Ram area 1.77 sq. in.

It should be mentioned at this point that, for the species that exhibit the smaller breaking loads, a compressometer with a ram area of one square inch has been used to increase the sensitivity of the testing apparatus. It is recommended that this procedure be followed on species with a specific gravity of 0.45 or less, based on oven dry weight and green volume. It is also recommended that, for any given series of tests, a hydraulic gauge should be used that has a range so that the average breaking load is near the center of the gauge range. With the two compressometers used at Syracuse, gauges with ranges of 100 and 250 psi have been found adequate for most conditions encountered. The compressometers and gauges are interchanged, of course, to meet various loading conditions.

Results obtained with the compressometer that has a one square inch ram area indicate true breaking load. Tests performed with the compressometer that has a 1.77 sq. in. ram area may be converted to a true breaking load basis by multiplying gauge pressure readings by 1.77. Results obtained with the two compressometers may then be compared directly.

Machining of specimen: Various tests have shown the importance of proper machining of the notched cleavage specimen. The specimen should be reasonably square cut in all planes, and the notch width and depth should be cut as accurately as possible. Accurate machining on such a small specimen requires well sharpened and maintained tools. This is especially important in the cross-cutting operation. A smooth cut is desired so that end-grain configuration may be readily observed.

Effect of location of defects in the glue line: To demonstrate the effect of defects located in different sections of the glue line in the notched cleavage specimen, areas of the glue line were blocked with a wax crayon. Fig. 10 shows the various treatments, each

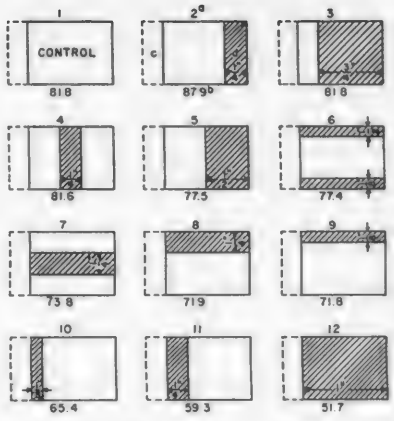


Fig. 10.—Treatments for blocked glue line study. a. treatment number; b. average gauge pressure in psi at breaking load for 10 specimens. Ram area = 1.77 sq. in; c. notch area; d. glue line in shaded portion blocked off with wax crayon.

of which was performed on a test sample from each of ten assemblies. Each assembly consisted of two pieces of hard maple 1/2 by 13/16 by 24 inches. The treatment patterns were randomly layed out on one of these pieces on the 13/16-inch face. The other piece was spread with urea-formaldehyde resin at a rate of 40 pounds per thousand square feet of glue line. The two pieces were then brought together to form an assembly that was cured in a high-frequency press.

After the assemblies were conditioned at 8 per cent EMC for one week, 1/32 inch was jointed from each face to remove glue squeeze-out. The individual cleavage specimens were then cross-cut from the assemblies, notched, and tested. This procedure for specimen preparation, except for the blocking step, is the same used for most of the other studies described in this paper. It is a simple procedure and readily lends itself to the study of different variables with a minimum of wasted time and material. Fig. 1 shows an assembly ready for gluing, one already glued, and one from which four specimens have been prepared.

The results of the blocked glue line study are given in Table 6a. It will be recalled that in the notched cleavage specimen the tensile stress perpendicular to the glue line is largest at the bottom of the notch, and decreases with distance from the notch until finally an area of compression is reached. When this information is applied to the present study, any defects in the glue line near the bottom of the notch should affect the breaking load of the specimen. On the other hand, a defect in the glue line at the other end of the specimen in the compression area should have little effect on the breaking load. A study of the treatments presented in Fig. 10 and Table 6a will confirm these assumptions.

Table 6a.—EFFECT OF BLOCKING DIFFERENT AREAS OF THE GLUE JOINT ON THE BREAKING LOAD OF HARD MAPLE NOTCHED CLEAVAGE SPECIMENS

Treatment No.[1]	Glued assembly number										
	1	2	3	4	5	6	7	8	9	10	Average
1	90[2]	94	85	83	70	62	80	73	100	81	81.8
2	110	87	90	91	90	83	77	77	80	94	87.9
3	90	70	95	85	76	79	66	102	73	82	81.8
4	93	89	82	90	80	64	83	84	66	85	81.6
5	82	80	89	80	73	60	62	91	82	76	77.5
6	86	78	78	74	71	68	80	75	74	90	77.4
7	89	70	86	80	70	52	70	70	70	81	73.8
8	77	70	67	72	74	72	69	69	74	75	71.9
9	90	85	59	72	68	62	70	80	60	72	71.8
10	93	56	60	70	60	55	69	68	52	71	65.4[3]
11	65	48	57	66	62	59	46	60	60	70	59.3[3]
12	72	30	60	49	40	44	42	60	55	65	51.7[3]
Average	86.4	71.4	75.7	76.0	69.5	63.3	67.8	75.8	70.5	78.5	73.5

[1]See Fig. 10 for description of treatments.
[2]Gauge pressure at breaking load in psi. Ram area 1.77 sq. in.
[3]These treatment means are significantly different from the control treatment No. 1, according to Tukey's test of differences (11). Level of significance—five per cent.

Table 6b.—ANALYSIS OF VARIANCE FOR BLOCKED GLUE LINE STUDY

Source	D.F.	SS	MS	F
Assembles	9	4,472	496.9	7.83[1]
Treatments	11	11,900	1,081.8	78.31[1]
Within	99	6,282	63.45	
Total	119	22,654		

[1]Significant at the 1 per cent level.

The fact that treatment number 2 resulted in higher breaking loads than the control treatment number 1 is probably merely a chance happening due to the small number of samples in each treatment. The only treatments found to be significantly different, at the 5 per cent level, from the control treatment were treatments 10, 11 and 12, all of which had blocked areas near the notch. Some of the other treatments, notably treatments 7, 8, and 9, showed breaking loads consistently lower than the control treatment, but the differences were not significant because of the variability demonstrated in the assemblies. The same study, if performed on a larger number of specimens, would probably show that some of these treatments result in significantly lower breaking loads. Treatments, 2, 3, 4, and 5, in which the area close to the notch was free of defects, showed results similar to the defect-free specimens.

The results for treatment number 12, the supposedly totally blocked glue line, indicates that complete blocking was not achieved in the waxed area. The resulting effect was a degradation of the bond in the waxed area rather than a complete elimination of the bond.

The results of this study indicate that the notched cleavage specimen will readily expose regions of poor bonding in the glue line, but would be less sensitive in its ability to detect small local defects, except where they occur near the notch.

Application of the Test Method

At Syracuse, the notched cleavage specimen has been used extensively for the evaluation of high-frequency gluing variables. Test specimens can be prepared and tested within five minutes after they are glued to determine whether glue lines are adequately cured. The specimen has also been used for screening of glues for given uses, testing of glue bonds in wood to evaluate the effects of various machining variables, and to determine the effects of accelerated weathering on glue bonds.

Other proposed uses for the specimen include: 1) quality control in edge-gluing operations, 2) testing of laminated wood constructions, 3) evaluation of internal bond strength of platen-pressed particle boards, 4) testing of glue bonds in laminated hardboard and particle board assemblies, 5) testing of adhesives, where the converging face-grain specimen would be used to force failure into the glue line, and 6) standard testing procedure for edge-glued panels.

A study is now being initiated to modify this testing procedure for the evaluation of the internal bond strength of platen-pressed particle boards. A preliminary study has indicated that such a test shows promise for evaluating this property in particle boards.

Perhaps the most important use for the notched cleavage testing procedure will be for testing glue bonds in edge-glued panels. Alan Marra (9) has stated very well the motive behind the development of the notched cleavage testing procedure. It was felt that no suitable test existed for the proper evaluation of edge-glued wood panel constructions. The testing procedure herein described has been developed to meet this need.

Conclusions

1. The notched cleavage specimen has filled a gap in testing procedures for glue bonds in wood. It is readily applicable to the testing of glue joints in edge-glued panels, a product which has not been adequately controlled because of the dearth of readily applied testing techniques. The notched cleavage specimen develops stresses that closely approximate the stresses due to moisture content changes in an edge-glued panel in service.

2. The variables that affect the breaking load for the notched cleavage specimen are easily controlled if it is desired to keep variability at a minimum. It is possible to control these variables to achieve a coefficient of variation of 8 to 10 per cent.

3. A thorough understanding should be had of the variables that affect test results before the specimen is used in any evaluation program.

4. The testing techniques herein described are simple to perform and relatively fast, which make the test applicable to quality control programs in the wood-using industry.

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Strength of Second-Growth Douglas-Fir

IN TENSION PARALLEL TO THE GRAIN[1,2]

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Second-growth coast-type Douglas-fir has about the same strength as old-growth wood in tension, and can produce wood with a high specific gravity. Other variables may influence tensile strength more than specific gravity does.

In recent years, there has been an accelerated demand for knowledge about coast-type, second-growth Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in the Pacific Northwest (3).[3] Most compiled information about mechanical properties of Douglas-fir has been based on old-growth timber (8). The increasing conversion from old-growth to second-growth material provided impetus for this study.

Not only was little known about mechanical properties of second-growth Douglas-fir, but even less was known generally concerning the strength of wood in tension parallel to the grain (19). In the past, because wood exhibits great strength along the grain, and because of lack of practical fasteners, it was uncommon for a clear, straight-grained piece of wood to be pulled apart lengthwise before the fasteners failed (17). Because of these factors, interest in improving tension testing did not advance as rapidly as mechanical testing of other structural properties such as static bending, compression parallel to grain, and shear. Recent developments in the improvement of adhesives and fasteners, and shortage of large, clear, structural material has ushered in a new era of wooden truss designs and engineered beams. For the first time, acquiring knowledge about tension parallel to the grain has assumed an important status.

Objective of the Study

This study provided the following information about second-growth Douglas-fir:

1. Average tensile strength parallel to the grain by means of the standard ASTM (1) test specimen.
2. Specific gravity data.
3. Effect of growth rate, specific gravity, and type of sampling on tension parallel to grain.

Associated Work

In 1954, a cooperative project was started by the Forest Research Division of the Oregon Agricultural Experiment Station and Oregon Forest Products Research Center. Designed as a continuing effort, it was intended to increase basic knowledge about second-growth Douglas-fir. Preliminary investigations were conducted in the summer of 1955 by Snodgrass under the subproject title "The Effect of Knots and Other Characteristics on the Tensile Strength of Douglas-fir Dimension Lumber."

In 1956, an interim study (11) was undertaken to develop and compare a round tension test specimen to ASTM standard D 143. The round specimen did not prove to be more satisfactory, so effort was directed toward improving fabrication of the standard specimen and the testing method. The history and evolution of this specimen is discussed by Markwardt and Youngquist (9) in their report concerning methods of tension testing.

In 1957, the present study was started as another sub-project under the sponsorship of the two Oregon agencies.

Tensile Strength: Only limited data are available on clear wood speci-

Typical even-age stand of second-growth Douglas-fir.

Typical stand of old-growth Douglas-fir.

The Author: Antone Van Vliet holds BS and MS degrees from Oregon State College, and is currently an instructor in wood technology.

[1] A 1958 Wood Award entry. Part of a thesis submitted for the MS degree at Oregon State College.

[2] Project was sponsored by the Forest Research Division, Agricultural Experiment Station, OSC, and the Oregon Forest Products Research Center. Technical Paper No. 1122, Oregon Agricultural Experiment Station.

[3] Numbers in parentheses refer to the Literature Cited at the end of this paper.

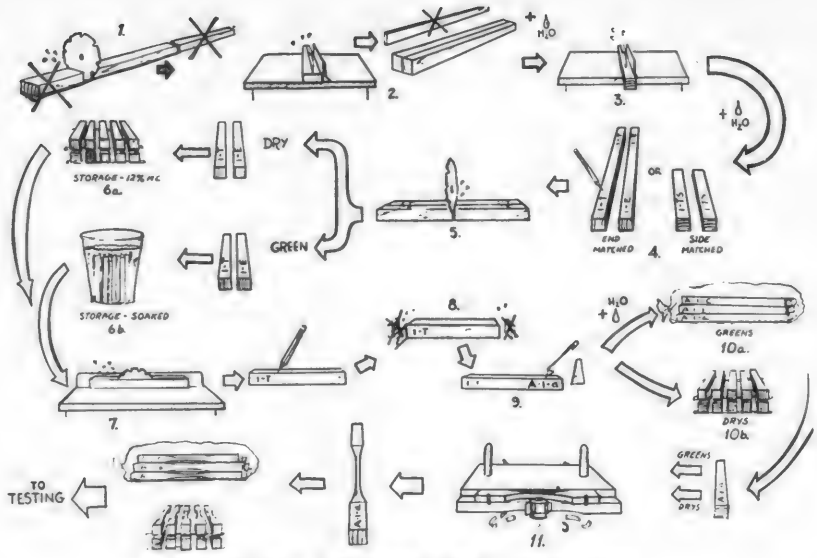

Fig. 1.—Steps in fabricating the tension specimens.

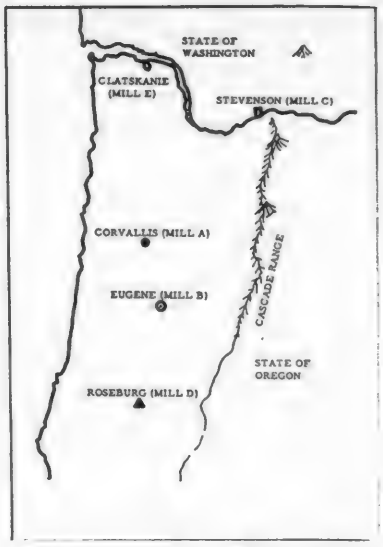

Fig. 2.—Location of mills (areas) where coast-type second-growth Douglas-fir was selected.

mens of Douglas-fir in tension parallel to grain. Values on old-growth range from 13,830 psi (8) to 19,900 psi (9) on material in the air-dry condition (about 12 per cent moisture content). The average for unseasoned (green) wood is 12,980 psi (8). With the tests for both dry and unseasoned wood combined, only a few hundred tests represent the total work done to date on old-growth.

In second-growth, 40 tests (11) yielded average values of 13,090 psi (12 per cent moisture content) and 10,038 psi (unseasoned) in material of 2.5 to 5 rings per inch.

Specific Gravity: In work concerning specific gravity there is considerable information available. Snodgrass (15), in a study of young-growth (second-growth) Douglas-fir lumber, found an adjusted specific gravity value (oven-dry weight, green volume) of 0.43, which agrees closely with Drow's (4) analysis of coast-type second-growth material. One of the heaviest contributors of basic data has been Smith (13, 14) who calculated specific gravity averages that ranged from 0.39 to 0.44 (oven-dry weight, green volume) for wide-ringed wood. McKimmy (10) computed a figure of 0.46 in a study, which closely approximates 0.45, the established specific gravity for the old-growth segment of the species.

Snodgrass found 0.49 as the dry specific gravity (oven-dry weight, oven-dry volume) for second-growth Douglas-fir.

The Wood Handbook (19) and Lewis (7) gave 0.48 and 0.47 respectively for old-growth Douglas-fir based on oven-dry weight and volume at 12 per cent moisture content. A higher figure would be evident if these values were changed to an oven-dry weight, oven-dry volume basis.

Growth-Rate: Growth-rate, or rings per inch, has been used as a practical way for dividing wood into groups for study as well as a variable considered in statistical analysis of factors related to wood quality.

There is no general agreement as to the effect of growth-rate upon wood. Relationships between growth-rate, specific gravity, and percentage of summerwood were included in several of the previously mentioned works. Percentage of summerwood was not discussed in this study because it has been found to correlate closely with specific gravity.

When the variables of site, crown class, geographical location, age of tree, and height in tree were included, McKimmy (10), Wellwood (18) and Paul (12) provided interesting conclusions. To acquire a more complete background in the complexities between these variables in wood, however, the wealth of work done on other species should be investigated. Two excellent bibliographies can be found in a bulletin by Larsen (6) and a book by Trendelenburg (16).

WHAT THIS RESEARCH MEANS

There has been a large volume of information collected over the last 30 years on the mechanical properties of wood.

Data on old-growth Douglas-fir comprise a major contribution to the above effort, with the one exception —strength in tension parallel to grain. Knowledge about this property has been limited, and for a good reason: previously wood seldom failed in direct tension before fasteners or adhesives yielded.

With new improvements in design, mechanical fasteners, and glues, wood has entered the modern structural fields. Tension property values are now important and someday may be accounted for in stress grading.

If we turn our efforts toward the new generation, young-growth Douglas-fir, we find only limited information in relation to its mature counterpart. Why young growth? In the Pacific Northwest, young-growth Douglas-fir is accounting for an increasing portion of the raw material that goes into lumber and its structural applications.

The results of 529 tests indicate that young growth is comparable with old growth average values in tension parallel to grain. In this mechanical property, young generations may prove themselves worthy representatives of Douglas-fir.

Editor

Procedure

Collection of Samples: Five areas, four in western Oregon and one in south-central Washington, were selected as those most likely to produce an adequate sample of coast-type, second-growth Douglas-fir (Fig. 2).

An individual mill that cuts a substantial portion of second-growth lumber was contacted in each area. These mills were classified as follows for the purpose of statistical analysis:

Mill	Location	Area from which logs came
Mill A	Corvallis, Oregon	Benton County
Mill B	Eugene, Oregon	Lane County to western slope of Cascade mountain range
Mill C	Stevenson, Washington	Skamania County; Wind River
Mill D	Sutherlin, Oregon	Douglas County
Mill E	Clatskanie, Oregon	Columbia County

The standard method (1) of tree and bolt selection was abandoned in favor of selecting individual pieces of lumber at sawmills (5). This was done to obtain a large number of specimen

Table 1.—AVERAGE DRY[1] TENSILE STRENGTH AND SPECIFIC GRAVITY, BY REPRESENTATIVE AREAS

Representative areas	Number of specimens	Average specific gravity	Average tensile strength, psi
Mill A	47	0.529	17,941
Mill B	66	.523	17,425
Mill C	54	.461	16,842
Mill D	64	.499	17,011
Mill E	41	.474	17,082
Mean	[2]	0.499	17,249
Standard error of the mean		.0039	282
Coefficient of variation		11.0%	25.1%

[1]12% moisture content.
[2]Total specimens tested, 272.

Table 2.—AVERAGE GREEN[1] TENSILE STRENGTH AND SPECIFIC GRAVITY, BY REPRESENTATIVE AREAS

Representative areas	Number of specimens	Average specific gravity	Average tensile strength, psi
Mill A	38	0.465	12,093
Mill B	73	.470	12,459
Mill C	50	.427	12,166
Mill D	65	.448	12,188
Mill E	31	.427	12,438
Mean	[2]	0.450	12,277
Standard error of the mean		.0035	188
Coefficient of variation		10.7%	22.6%

[1]Over fiber saturation point.
[2]Total specimens tested, 257.

ach representing an individual tree, rather than a small number of trees, each producing several specimens. By choosing this collection system, the following were expected to be achieved.

1. A large random sample (specimens from all mills) should give an adequate distribution of material from butt, middle, and top logs.
2. Site qualities should be adequately represented.
3. An economy of time and equipment should be gained.
4. A range of specimens could be gathered on the basis of rings per inch.

It was necessary to establish a criterion for selecting lumber piece specimens at individual sawmills. Dimension lumber, preferably 2 by 4 inches rough, or surfaced to 1⅝ by 3⅝ inches, was chosen as easiest to acquire and handle. Any length from 6 to 12 feet was satisfactory as long as 20 by 3⅝ inches, or 40 by 1⅝ inches of clear material was present for side matching or end matching the specimens. The material also had to have nearly flat or vertical grain, and a slope of grain no greater than 1 inch in 20 inches.

Six growth-rate classes were established to segregate the material, which ranged from 2.6 rings per inch to 22 rings per inch (Tables 3 and 4). Growth-rate class No. 1 was included to see if material with low ring counts provided adequate strength for future inclusion in structural grades.

A minimum of 60 pieces were collected at each mill, 10 in each ring-count group. This amount was believed to have been 50 per cent more than necessary for statistical analysis, to compensate for unnoticed defects, mismanufacture, or faulty breaks in testing, and still insure a minimum number of good tests for analysis. If time permitted, more than 60 pieces of 2 by 4 inch lumber was chosen. In a few instances, less than ten pieces were obtained for a given growth-rate class due to the nature of the second-growth Douglas-fir being cut by that particular mill.

The first attempt at collection was made by standing at the green chain and pulling the lumber according to a random numbers table. This method failed for two reasons:

1. Long periods of time were consumed standing and waiting for a particular piece to come by and then having to reject it because it did not meet the qualifications established.
2. The random numbers table often produced several numbers close together that were pieces from the same log.

Two alternative techniques of lumber piece selection then were tried in an attempt to produce a random sample. The first was to go through the entire day's production of 2 by 4 inch stock stacked in the yard. When a piece was chosen, several more layers would be removed from a pile before selecting another. The sample was kept random, and chances for two pieces from the same log or tree being picked were very slim.

The second technique was taking each piece at random from the green chain and waiting a short period of time to insure that stock from a different log was coming by. The piece was accepted or rejected after a large pile had been accumulated.

The choice of which technique to use was determined by the mill layout to avoid interference with the workers.

Each 2 by 4 inch piece was marked with blue crayon as to the location of clear material available between knots or other defects. The slope of grain was checked on both the wide and narrow face with a scribing tool and the ring count was measured to the nearest 0.10 inch with a metal tape.

A coded letter for the mill and a number for the ring count group was then placed on the piece. (Example: C-3 denotes Mill C and growth-rate class No. 3, 6.6 to 8.5 rings per inch.)

After loading the lumber on a stake-side truck, it was covered with burlap sacks and soaked with water to retain moisture en route to Corvallis.

The lumber was unloaded at the Forest Products Research Center, restacked, covered again, and kept wet with a sprinkler system until fabrication was possible.

Fabrication of the Standard Specimen: The steps from the 2 by 4 inch piece of lumber to the standard test specimen for tension parallel to grain are shown graphically in Fig. 1 and are described below.

1. The lumber was trimmed to leave 40 inches of clear material, depending upon defects present.
2. By means of an E-Z King feed mechanism on a table saw, the clear piece was ripped twice lengthwise at 1⅜ inches,

Table 3.—AVERAGE DRY TENSILE STRENGTH AND SPECIFIC GRAVITY BY GROWTH-RATE CLASSES

	Growth rate classes	Number of specimens	Average specific gravity	Average tensile strength, psi
1	2.6– 4.5 rings/inch)	44	0.456	14,401
2	4.6– 6.5 rings/inch)	54	.499	16,574
3	6.6– 8.5 rings/inch)	51	.506	17,113
4	8.6–10.5 rings/inch)	36	.518	18,467
5	10.6–12.5 rings/inch)	39	.494	17,902
6	12.6–22 rings/inch)	48	.520	19,322
Mean		[1]	0.499	17,249

[1]Total specimens tested, 272.

Table 4.—AVERAGE GREEN TENSILE STRENGTH AND SPECIFIC GRAVITY BY GROWTH-RATE CLASSES

Growth rate classes	Number of specimens	Average specific gravity	Average tensile strength, psi
1 (2.6– 4.5 rings/inch)	37	0.404	10,247
2 (4.6– 6.5 rings/inch)	52	.443	11,407
3 (6.6– 8.5 rings/inch)	51	.462	11,545
4 (8.6–10.5 rings/ nch)	44	.468	13,742
5 (10.6–12.5 rings/inch)	34	.450	13,428
6 (12.6–22 rings/inch)	38	.467	13,661
Mean	[1]	0.450	12,277

[1]Total specimens tested, 257.

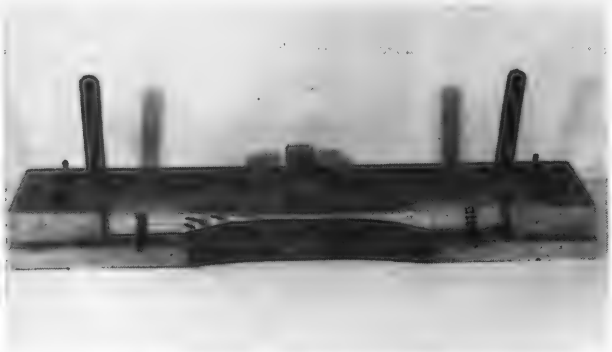

Fig. 3.—Standard jig for making the tension-parallel-to-grain specimen.

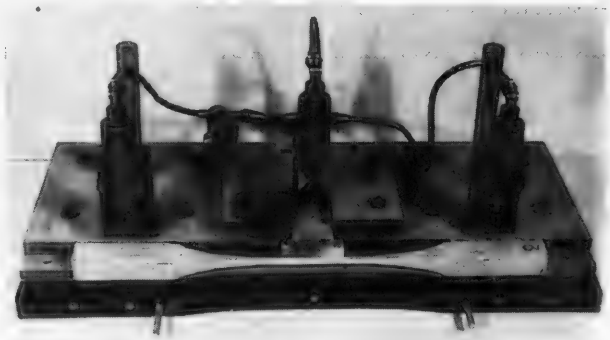

Fig. 4.—New air-operated jig for making the tension specimen.

which left two pieces 1⅜ by 1⅝ inches and a small slab, which was discarded. (From step 2 through step 5, all pieces were kept together as they had been in their original form, for matching purposes.)

3. After one mill's collection had been completed through step 2, each pair was fed again through the table saw, which cut the 1⅝ inch side down to 1⅜ inches. This now resulted in two rough blanks of 1⅜ by 1⅜ by 40 inches.
4. Each pair was rechecked for slope of grain and defects, and then remarked as shown in Figure 1, according to the following symbols:

   1 and up—consecutive numbers of pairs of specimens.
   T—test specimen.
   E—extra set, which could be used for another study if desired.
   S—Side-matched material only.

   In pieces where it was possible to get only 20 inches of clear material, there were no extra specimens.

5. The stock was trimmed into 20-inch lengths, which yielded four blanks: two T's and two E's. The T's were randomly separated, one for drying and one to remain green.

6a. The test specimens that were to be dried were stacked and stickered in the standard room. Conditions maintained were 62° F. wet bulb and 70° F. dry bulb, which yielded an equilibrium moisture content of 11.6 per cent to 12.5 per cent.

6b. The test specimens that were to be unseasoned (kept soaked) were kept in a large container filled with water while awaiting the next steps.

7. By means of a hollow-ground miter saw, each piece was edged on all four sides to one by one inch, and the specimen identification numbers were replaced.
8. The blanks were trimmed to 18 inches in length.
9. The finished blank was rechecked again for ring count and recoded as the following example.

   A—1-a means Mill A, growth-rate class No. 1 (2.6-4.5 rings per inch, specimen "a". These numbers were recorded so that their dry, matched, counterpart would be given the same designation.

10a. For unseasoned pieces, each ring count group was placed in a polyethylene bag and 50 ml. of water added. The bag was tagged as to mill and group, placed in the cold moist room to await shaping.

10b. When all the soaked samples had been finished through step 10a, the dry rough blanks in the standard room were ready for steps 7 through 9. To check whether they had dried to 12 per cent, a Delmhorst moisture meter[4] was used on randomly picked blanks. A minimum time of one month storage proved satisfactory to bring the pieces to equilibrium moisture content.

11. The technique used in the final stage of fabrication was similar to that followed at the U. S. Forest Products Laboratory (2).

[4] Model RCt with a 26E Electrode.

Equipment used to produce the standard ASTM test specimen (1) was a special air-operated jig, a three-blade shaper, and a dado blade set on a table saw.

The test specimen required shaping to a cross-section in the center of ⅜ by 3/16 inch. This requirement was slow and difficult to achieve on an old-model jig (Fig. 3) when a large number of specimens had to be produced. A new jig was developed (Fig. 4) to speed manufacture and still maintain accuracy.

The soaked specimens were done first and returned to their original bags. The dry samples were done in small numbers and returned to the standard room to await testing.

Measurements and Determinations Before Testing: Least dimensions at the center of each standard test specimen were measured to the nearest 0.0005 inch with a Dead Weight Micrometer (Fig. 5). Measuring was

Fig. 5.—Measuring least dimensions with the dead-weight micrometer.

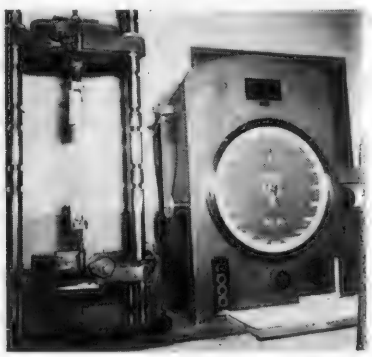

Fig. 6.—Standard ASTM specimen in the 20,000-pound testing machine.

Table 5.—ANALYSES OF VARIANCE OF TENSILE STRENGTH AND SPECIFIC GRAVITY TO DETERMINE EFFECT OF GROWTH-RATE AND LOCATION ON THESE PROPERTIES

Property	Source of variation	Degree of freedom	Sum of squares	Mean square	F value
Tensile strength (dry)	Growth-rate	5	658.5905	131.7181	4.83[2]
	Mills within growth-rate	24	653.9624	27.2484	1.46
	Error	242	4528.8111	18.7141	
	Total	271	5841.3640		
Tensile strength (green)	Growth-rate	5	433.4501	86.6900	13.74[2]
	Mills within growth-rate	24	151.4712	6.3113	.82
	Error	227	1741.0144	7.6697	
	Total	256	2325.9357		
Specific gravity (dry)	Growth-rate	5	0.118464	0.023693	2.04
	Mills within growth-rate	24	.279110	.011630	3.84[2]
	Error	242	.733401	.003031	
	Total	271	1.130975		
Specific gravity (green)	Growth-rate	5	0.114943	0.022989	3.71[1]
	Mills within growth-rate	24	.148890	.006204	2.67[2]
	Error	227	.526863	.002321	
	Total	256	.790696		

[1] 5% significance level.
[2] 1% significance level.

done by sliding the stick back and forth under the micrometer until the lowest figure was registered; this was also a check to see that the least dimensions were in the middle 2-½ inches of the specimen.

Sapwood and heartwood determinations were made by brushing one end of the piece with Ameroid[5]. Sapwood turns green and heartwood turns purple within seconds after application.

Testing Procedure: The specimen was held in a pair of specially designed grips very similar to those described by Bellosillo (2). Fig. 6 shows a specimen in the grips. The universal joint at the top grip aided in self-alignment.

A 20,000 pound Tinus Olsen testing machine continuously applied a load to destruction, at a head speed of 0.05 inch per minute.

Wedge-shaped moisture content sections were taken immediately after each test. The sections were from the reduced area adjacent to the failure. Special care was taken to keep these pieces at their original moisture content until they were weighed. After they were weighed, the specimens were oven-dried in preparation for determination of specific gravity.

Specific Gravity Determinations: A special weighing yoke used on a Mettler balance saved time in making volume measurements by the water-immersion method. Equations for specific gravity determinations are shown below:

$$V = (Mm + Aw) - Ai$$

$$\text{Specific gravity} = \frac{D}{V}$$

V = weight in grams of a volume of water equal to the volume of the sample.

D = oven-dry weight of the sample in grams.

Mm = weight of the sample in grams at green or 12 per cent moisture content conditions.

Aw = weight of the apparatus (yoke, needle, etc.) in grams.

Ai = weight in grams of the apparatus plus the sample immersed in water.

[5] Total Alkalinity Indicator No. 4A diluted with one part distilled water.

Test Results

Results of 529 tests are shown in Tables 1, 2, 3, and 4. Average tensile strength and specific gravity data are given. The 17,249 psi dry value for tensile strength of second-growth Douglas-fir ranks high in the range found for old-growth material tested at 12 per cent moisture content. The green value, 12,277 psi, were extremely close to the known value of 12,980 psi for old-growth Douglas-fir.

The mean specific gravity (green volume) of 0.45 was comparable to published values in other reports (10) on second-growth Douglas-fir. Such was not true of the mean specific gravity (12 per cent volume) of 0.50, which was slightly higher than previously reported values.

In general, tensile strength and specific gravity, increased as number of rings per inch increased.

The uneven total number of samples of dry and unseasoned material should be pointed out since matched samples have been emphasized throughout the procedure. A small percentage of specimens were eliminated by a highbreak or a sheared collar; the result was a dry or unseasoned specimen without its matched counterpart. The only purpose of matching was to analyze similar material separately.

Analysis of Variance (Table 5): *Tensile strength:* The difference between averages of the representative areas (mills) *within* a growth-rate class did not contribute to the error of measuring tensile strength. In other words, if all the specimens with a ring count of 2.6 to 4.5 rings per inch (growth-rate class No. 1) were collected from five areas (mills), the average tensile strengths of each area would be similar. This situation was also true for the other growth-rate classes.

There was a noticeable difference among the average test values of the ring-count classes. Generally, wood with a high ring count tested stronger than wood with a low ring count. This relationship was found for tension tests of both dry and unseasoned pieces within the range of growth-rates studied.

Specific gravity: Within each growth-rate class, the specific gravity averages between the areas (mills) were significantly different for both dry and unseasoned Douglas-fir. This amount of change between areas may be caused by variables not considered in this study, such as environmental and hereditary factors, age of wood, and position in the tree.

It was interesting to find no significant difference between the average specific gravities of the growth-rates themselves in dry material, but there was a difference in the green material. A possible explanation for dry wood was that a small change in specific gravity accounts for a large change in tensile strength ,otherwise the analysis on tensile strength would not seem logical. Smith(14) found that the

Table 6.—LINEAR REGRESSIONS, REGRESSION COEFFICIENTS, CORRELATION COEFFICIENTS, AND PER CENT VARIATION EXPRESSING THE RELATIONSHIP BETWEEN TENSILE STRENGTH, SPECIFIC GRAVITY, AND GROWTH RATE

Regressions	Regression equation $Y_x = Y - b(X - \bar{X})$	Regression coefficient b	Correlation coefficient r	% Variation accounted for $100\ r^2$
Y (dry tensile strength) on X (dry specific gravity)	$Y_x = 41{,}345X - 3{,}382$	41,345	0.5753	33.10
Y (green tensile strength) on X (green specific gravity)	$Y_x = 23{,}070 - 1{,}896$	23,070	0.4254	18.10
Equation for confidence limits	$Y_x \pm [t.025]\left[\sqrt{\frac{1}{n} + \frac{(X-\bar{X})^2}{SS_x}}\right]\left[\sqrt{\frac{SS_y - \frac{(SP)^2}{SS_x}}{n-2}}\right]$			

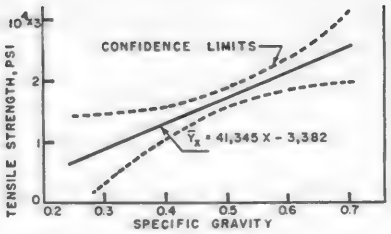

Fig. 7.—Regression of dry tensile strength on dry specific gravity.

growth zone or number of rings per inch accounts for a low percentage of variability in specific gravity.

Regression Analysis (Table 6): Purpose of the regression analyses was to show the effect of certain variables, dependent and indepedent, upon each other, within the limitations of statistics.

Tensile strength on specific gravity: The lines plotted from equations in Table 6 appear in Figs. 7 and 8, and are linear. For dry material, the test values came closer to falling on the calculated line, and specific gravity alone accounted for 33.10 per cent of the total variation. For each unit increase in specific gravity, dry Douglas-fir exhibited a higher strength value than the unseasoned, as demonstrated by a steeper line in Fig. 7 than in Fig. 8. Dotted lines represent confidence limits.

Conclusions

1. Results of this study produced two averages for tensile strength of second-growth Douglas-fir, one for material at 12 per cent moisture content and another for unseasoned material. These values could serve as a guide for later studies.

Based upon results from testing 529 specimens, strength of second-growth wood appeared to be comparable to that of old-growth Douglas-fir in tension.

2. The specific gravity averages added to known data show that second-growth material could produce wood with as high a specific gravity as that published for old-growth wood.

3. When growth rate was not considered, tensile strength increased as specific gravity increased. This is shown in Figs. 7 and 8. No conclusion could be drawn as to the effect of specific gravity on tensile strength in this study. Specific gravity accounted for a low percentage of variation in strength according to the regression analysis, but did not explain the way growth-rate affected tensile strength without affecting specific gravity. Therefore, other variables may influence tensile strength more than specific gravity does.

4. The sampling technique used in this experiment offered an economical and practical way of estimating the population average.

5. In the past, the value of the modulus of rupture in static bending was used as an estimate of tensile strength, which was a conservative approach. The average tensile strength of second-growth Douglas-fir was 161 per cent higher for wood at 12 per cent moisture content and 141 per cent for unseasoned wood than published modulus of rupture values (19) for old-growth wood.

6. These data can be used as an aid in calculations of basic stress, working stress, and strength ratio.

Demand for tension grades may materialize in the future, through design of improved fasteners and adhesives. At that time, data should be available for computations. Reliability of structural tension-graded lumber will depend upon basic information of this nature.

Recommendations

The following recommendations are included to assist future workers.

1. A large sample should be taken (more mills representing more areas) to check the method used in the present study.

2. Other methods of segregating the specimens should be tried. It seems doubtful that a more practical criterion than growth-rate will be found at present.

3. If specific gravity remains a good judge of strength, then additional investigations are needed to understand the interrelationships among growth-rate, specific gravity, and other variables on tensile strength in Douglas-fir.

4. It should be established whether second-growth wood is sufficiently different from old-growth in tensile strength to warrant segregation.

5. Fabrication of a large number of specimens was still tedious, even with an improved jig. A more rapid method should be found.

6. The standard tension specimen is not perfect; new designs should be tried.

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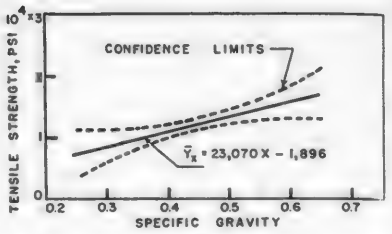

Fig. 8.—Regression of green tensile strength on green specific gravity.

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Tropical Species Gaining in World Hardwood Markets

The market for hardwoods is characterized by a multiplicity of specialized requirements, the wide range of species utilized commercially, and the diversity of qualities they display. Since the war, there has been a growing demand for large-sized, good quality hardwood logs, both for the manufacture of veneers and sawnwood, and, to meet this demand, there has been a rapid expansion of the use of tropical timbers. Alongside this, there has been, in temperate regions, a weakened market for medium and low grades of indigenous sawnwood, but an increased demand for small roundwood of broadleaved species. There has been, therefore, a change in emphasis both in the sources of supply for the world trade in hardwoods and in the pattern of consumption.

The position of tropical species in world markets is now well established. Their size and quality make them suitable for many of the uses to which hardwoods are put, and advances in technology will continue to increase the range of tropical timbers that can be made available and used.

In the past 10 years, in the temperate zone, a shift in the pattern of hardwood consumption has occurred from sawlogs to veneer logs and pulpwood. In the manufacture of pulp, plywood, and the modified wood products that are increasingly gaining ground as substitutes for solid wood, an extensive and expanding outlet is appearing for hardwoods, in particular the small and low-grade roundwood of which there is at present a chronic surplus in Europe, and, to a lesser extent, in North America. Within the limits imposed by the economics of harvesting, processing, and transport, it is in these categories that the major increases in the future use of hardwoods is likely to occur.

A world summary of production, export, import, and consumption of hardwoods appears in UNASYLVA, Vol. 12, No. 4, 1958.

WORLD-WIDE
Forest Products News

Dr. Tom Gill, Director of Charles Pack Foundation, addressed the Philippine Lumber Producers' Ass'n in Feb. on a survey of the causes of depletion and destruction of the Philippine forests. Gill's proposals, based on a visual survey made at the request of the Phillippine government, will help guide congressional action.

Forest Products Publications Scanning World Wide

● Japan

On the Rotary Cutting of Small Logs. Lathe Back-up Rolls and Results of the Operations. Tadahiko Kanauchi. Journal of the Japan Wood Research Society. V. 4, No. 6. (English summary).

For cutting to smaller diameter, the apparatus of lathe back-up rolls was made on the basis of the fundamental experiments. This report is concerned with the apparatus of back-up rolls and results of the operations. It gives loads to a cylinder peeling bolt by compressed air.

Two pairs of rollers hold the peeling bolt while it is cut to a small diameter, and they are raised after cutting. The positions of the rollers can be changed.

The apparatus is able to give loads of 1000 kg with the angle of about 20 degrees to the vertical line of the peeling bolt. The effects were investigated on an 8-foot rotary lathe running at about 100 rpm.

Results obtained are summarized as follows:

1. With the apparatus, the cutting of small logs was made easy and vibration was not conspicuous. When the amount and positions of loads were suitable, it was observed that the irregularity of veneer thickness and peeling core diameter decreased.

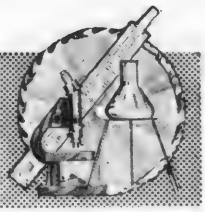
2. If length of a log is 8 feet and positions of loads divide it into three equal parts, required loads for cutting to the diameter of about 100 mm are assumed to be as follows: That for 1.0 mm veneer of Kalopanax is about 500 kg, that for 1.2 mm veneer of basswood about 400 kg, and that for 0.8 mm veneer of birch about 570 kg. The apparatus has proved to be profitable in order to get more and better veneer from each log in the case of peeling down to smaller cores.

● Germany

Critical Speed of Moulder Spindles. Albert Bronner. *Holz a.R. uW*, V. 16, No. 12. (English summary).

Critical speed (RPM) frequently causes the spindles of modern wood milling machines to break. Their nature and effects were theoretically examined in the present article. For standardized spindles, the critical number of revolutions could be calculated under simplifying assumptions, and the influence of non-computable factors could be estimated. Combining spindle and tool, there are two limit values for n_k. The lower value indicates the maximum speed, including a certain security state. By supporting the spindle with an upper bearing, the number of revolutions can be increased considerably. The results of these calculations are confirmed by numerous experiments. The experiments proved above all that simplifications in calculating the results with endangered spindles do not lead to inaccuracies.

Abstracting the Literature



Materials of Construction

Materials and Methods of Architectural Construction. Parker-Gay-MacGuire, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., June 1958, 724 pp. $12.00.

Revised edition presenting and explaining modern design formulae and current working unit stresses. Many of the previous figures have been revised and many new ones added. New safe load tables have been added to conform with present-day working stresses. Approximately 70% of the text has been re-written. [BRI Abstracts, Oct. 1958]

Douglas Fir Use Book. West Coast Lumbermens Assn., 1410 S. W. Morrison St., Portland 5, Ore., 1958, 294 pp., $5.00.

All material from the previous edition of this book has been brought up to date and the range of information on many subjects has been expanded, particularly in the chapters on glued laminated structural members and wood preservation. A new section on lateral force design has been included, plus data on design loads, and all the important timber fastening devices and connectors. The structural data and design tables which make up the book are intended for use of architects, engineers and students preparing for such professions. [BRI Abstracts, Oct. 1958]

Dimensional Stabilization

Goto, Teruo, Araki, Mikio, and Kadita, Sigeru. Studies on the dimensional stabilization of wood. I. On β-naphthylamine-impregnated wood. *J. Japan Wood Research Soc.* 4, no. 4: 131–3 (Aug., 1958). [In Japanese and English]

Heartwood specimens of Japanese cypress *(Chamaecyparis obtusa)* and birch *(Betula nikoensis)* were immersed in molten 2-naphthylamine at 130° C. for 1 hr., followed by removal of excess impregnant by 2, 30, or 80-min. immersion in acetone. Treatment with 2-naphthylamine greatly improved the dimensional stability of the wood but increased its specific gravity, presumably through a bulking (swelling) effect. [Bul. Pap. Chem. V. 29, No. 4]

Kiln Drying

Kiln Drying Partial Loads. Curzon and Co., India.

When a kiln is not completely full for timber seasoning, it is usually most uneconomical because heated air takes the line of least resistance. Thus it will flow over the timber pile and only a very negligible quantity of live steam or heated air will pass through the charge at the bottom half of the kiln.

To overcome this difficulty, this company has devised and manufactured an inexpensive system of baffle-panels, which are suspended from the center of the kiln ceiling. To ensure flexibility, it is made in four sections which are of 2 ft., two of 1 ft. and one of 6 in. By permutation of these, the drop of the central baffle can be adjusted from 6 in. to 4 ft. 6 in. in stages of 6 in. To deal with partial loads that are short in length as well, longitudinal panels are also suspended from the ceiling down to the kiln floor. [F. D. C. Tech. Bull. 41, V. 7, No. 41]

Barking

Sucksdorff, Bjorn. A new device for the soaking of wood. *Svensk Papperstidn.* 61, no. 9: 279–81 (May 15, 1958). [In English; Swedish and German summaries] *cf.* B.I.P.C. 28: 1417–18.

The importance of soaking dry wood before barking is emphasized. The cambium must be wetted to facilitate bark removal. A soaking canal is described in which a continuous pile of wood is conveyed into hot water and out again without clogging. The high soaking temperature used (75–80° C.) permits savings in soaking time. The installation of two soaking canals at the Kymmene AB, Finland, one for spruce and one for birch, is described. They have performed satisfactorily since their inauguration 3 yr. ago. An I.K.R. parallel pocket barker installed after the canal requires only 20% of the power needed by barking drums and causes practically no wood losses. [Bul. Pap. Chem. V. 29, No. 1]

Finishing

Exterior Finishes For Redwood. (California Redwood Assn., 576 Sacramento St., San Francisco 11, Calif., Jan. 1958, 4 pp, free.

Details various natural finishes, the manufacturers of each and the finishing system to be used. There are also recommendations as to prevention of failures and methods of refinishing. [BRI Abstracts, Oct. 1958]

Cerric Catalysed Resistant Ebony Finish. Cellon Ltd.

Modern design has popularized the ebony finish on many articles of furniture and furniture components, such as chairs, sideboard and table legs and table tops, and so forth, and an extremely durable finish is required. While cellulose offers a reasonable finish, a harder, mar-proof film has been developed by this firm. This is claimed to be scratch, abrasion, heat, and spirit resistant, with a processing time approximately equivalent to that for cellulose lacquer.

The suggested process consists of either a black base stain or a black rubbing filler, followed by one or more coats of the special resistant ebony finish. For top quality production, a further application of one coat of Cerric satin flow coat will provide additional appearance and "feel". The mixed pot-life is limited but is claimed to be sufficient for a full day's production. [F. D. C. Tech. Bull. 41, V. 7, No. 41]

Chemical Utilization

Schoenemann, K. The improved Rheinau process of wood hydrolysis. *Chim. & Ind.* (Paris) 80, no. 2: 140–50 (Aug., 1958). [In French, English, German, and Spanish summaries]

The Rheinau process consisted essentially in hydrolyzing wood chips, recovering the acid by vacuum distillation, and removing excess water from the distillate with calcium chloride. The process has been modified to permit the saccharification of waste materials such as sawdust and agricultural residues. The material to be saccharified is prehydrolyzed with 35% hydrochloric acid in the first two of a six-tower assembly. The hydrolysis proper, with 41% hydrochloric acid, is carried out in the remaining towers. The recovery process reduces the consumption of hydrochloric acid to 5.6% of dry wood weight. The process yields, on the basis of dry wood weight, 28% glucose hydrate and 35% of other sugars. Activated lignin can be condensed with phenol or formaldehyde to yield resins of the Novolak type, or used as filler in the manufacture of rubber. The Rheinau process presents a partial solution of the problem of waste-materials utilization. Its production costs compare favorably with other methods of producing sugars. [Bul. Pap. Chem. V. 29, No.]

Hossfeld, Ralph L., and Hunter, William T. The Petroleum ether extractives of aspen bark. *Tappi* 41, no. 7: 359–2 (July, 1958); *cf.* B.I.P.C. 28: 1069–70.

Normal aspen bark gave a 3.8% yield of petroleum ether extractive. Solvent fractionation and chromatographic column separation on alumina of the saponification products led to the identification of lignoceric acid, linoleic acid, β-sitosterol, ceryl alcohol, and unsaturated β-hydroxyster[illegible] and a hydrocarbon. Glycerol was isolated from the aqueous saponification residue. [Bul. Pap. Chem. V. 29, No. 2]

The preparation of abstracts from the world literature is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts used in the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles. Copies or additional information can not be supplied by FPRS or the abstract journal.

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BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin, by the Institute of Paper Chemistry.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL, published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England.

Finishing

Expanding Opportunities for Water Paints. (from Battelle Tech. Rev., 9/58)

As regards water-thinnable emulsion paints, the major problems to be solved in the future are listed as: 1) the development of satisfactory adhesion of exterior paints to all substrates; 2) formulation of gloss decorator enamels; 3) production of a hard, mar-proof, industrial enamel; 4) development of good water resistance in a reasonable time; and 5) inhibition of the rusting of iron and steel in the presence of water-containing emulsion paints. [BRI Abstracts, Dec. 1958]

Paint, Varnish, Lacquer and Related Products. Compilation of ASTM Standards D–1, American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., July 1958, 900 pp., $8.25.

This volume is a compilation of all ASTM specifications, methods of test and definitions pertaining to paint, varnish, lacquer and related products. It supersedes the Jan. 1955 edition, and contains 27 standards which are new, revised or have had their status recently changed, out of the total of 200 in all. In addition, 61 of these standards bear the stamp of approval of the Federation of Paint and Varnish Production Clubs. [BRI Abstracts, Oct. 1958]

Logging

Baker, T. St. Regis takes on whole trees. *Pulp & Paper* 32, no. 10:134 (Sept., 1958).

At its Fargo, Fla. woodlands headquarters, the St. Regis Paper Co. has undertaken an integrated pulpwood-sawlog harvesting operation which reduces logging costs, logging wastes, and manpower requirements and permits improved mechanization in woods operations. The trees are felled and trimmed in the forest and hauled in whole log form to the chip mill, where they are barked by a 30-in. Nicholson Rotobarker. While being conveyed from barker to chipper, sawlogs and the like are sorted out from the pulpwood. The pulpwood, still in whole tree form, is chipped in a Hansel chipper, and the chips are conveyed directly to hopper cars for transportation to Jacksonville. 5 figures. [B.I.P.C., V. 29, No. 6]

Sawing

Thunell, B. Stretching plates for gang-saw blades. *Svensk Papperstidn.* 61, no. 18B:707 (Commemorative issue, Oct. 10, 1958). [In Swedish; English and German summaries]

Gang-saw blades should be fitted into the sash or frame with sufficient tension to insure that the stresses in the tooth-edge line impart adequate stiffness to the blade during sawing. The transfer of forces is achieved by riveting stretching plates to the ends of the blades. Plates and riveted joints are sometimes deformed by the large forces transmitted in industrial operations. Hence, the stress distribution in riveted joints and in the surrounding portion of the blade has been studied under various conditions, using both new and worn blades and both centric and eccentric loading. These tests have shown that the present method of fitting blades into the sash does not meet all justifiable demands and that certain improvements should be possible. 23 figures and 3 references. [B.I.P.C., V. 29, No. 6]

Modular Construction

Modular Measure Works for Architects, Producers, Builders. Modular Building Standards Assoc., 2029 K St., N. W., Washington 6, D. C., 1958.

This pamphlet details the advantages of using modular measure for architects, builders, and producers, and gives pertinent details. It is illustrated with modular and non-modular floor plans. The absence of fractional dimensions is shown in the former. [BRI Abstracts, Dec. 1958]

Modular Measure, A Review. Housing and Home Finance Agency, Washington 25, D. C., March 1958, 7 pp, free.

This pamphlet is for those who want a quick review of the current status of modular coordination in the building industry. It is an appraisal of its acceptance in the United States and a resume of its history and significance at home and abroad, as well as its use by Federal agencies. Use of modular measure abroad by the European Productivity Agency of the Organization for European Economic Cooperation is discussed. [BRI Abstracts, Oct. 1958]

Plywood, Particle Board Subjects of Pacific Northwest Section Meeting

Summarized here are the highlights of the papers presented at the February, 1959 meeting of the Pacific Northwest Section, FPRS. These papers will be reviewed for subsequent full publication in the FOREST PRODUCTS JOURNAL.

Termite Protection of Particle Board. G. E. Brown and H. Alden, Monsanto Chemical Co. This research was undertaken to solve some of the problems that could arise when particle board is used in termite-infested areas. The investigation was designed to study the amount of pentachlorophenol needed for protection, and estimate the length of time this protection would be effective. The method of addition and the effect of the preservative on board properties were also investigated.

Laboratory and production samples made with either phenolic or urea binders and containing various amounts of pentachlorophenol were exposed in Florida test plots, and were evaluated after specific time intervals. To date, samples exposed for six months and one year have been evaluated.

On the basis of this study and previous work, one per cent of pentachlorophenol based on the ovendry weight of the wood is recommended.

Sonic Detection of Blisters in Plywood. D. E. Miller, Ottawa Lab, Forest Products Laboratories of Canada. For the purposes of this discussion, blisters were defined as areas of no bond between two adjacent plies. The study originated from the need to inspect production plywood rapidly and mark these hidden blisters.

Several approaches were tried. A hard-bristled brush, very much like those used in electric floor polishers, has proven very successful. A microphone attached to the brush picks up the sound of the brush as it revolves over the moving panel. The first work was done on ¾ inch, 7-ply Douglas-fir plywood containing artificial blisters between the third and fourth plies. Test runs consistently brought out differences in sound between blistered and bonded areas. The blister detector filters out all frequencies except the 8,000 cps signal used, amplifies the sound, and uses changes in sound intensity as the basis for locating blisters.

Plywood must now be inspected on both sides, but the design may be changed so that both sides can be inspected simultaneously. A proposed industrial model is designed to operate on sanded panels at a feed speed of about 30 fpm. It would mark location and size of blisters. Another model would operate behind the trim saws at speeds up to 100 fpm, but would only mark those panels that contain blisters. A portable model is currently being evaluated. It weighs 10 pounds and has a 1500 rpm brush.

Floor Tile from Planer Shavings. C. H. Burrows, Oregon Forest Products Research Center. Floor tile with adequate wear resistance was made from wood planer shavings. Ponderosa pine shavings were used in this study, but other species would probably perform equally well with minor modifications in manufacture.

Results of laboratory tests showed that physical properties of experimental tile were equivalent to or better than properties of linoleum and cork tile. Estimated manufacturing and retail costs for tile of ponderosa pine planer shavings compared favorably with cost of most commercial flooring materials.

The experimental floor tile can be made by standard techniques for manu-

facturing particle board, with minor modifications or additions to equipment. It appears likely that a system could be engineered to manufacture tile by a "scaled down" production system for particle board. Such a system might be integrated into a sawmill or planer mill to increase utilization of residues.

The Effect of Flake Dimensions on Board Properties. J. Brumbaugh, Washington State Institute of Technology. Four variables were investigated in this study: flake length, flake thickness, percentage of resin binder, and board specific gravity. Experimental boards were evaluated on the basis of modulus of rupture, internal bond, a 24-hour water soak test, and linear expansion.

The results indicated that there is no optimum flake for all properties. Long, thin flakes increase the MOR, whereas short, thick flakes are superior as far as internal bond is concerned. From a dimensional stability standpoint, short, thin flakes are superior.

Exterior Gluing of Low-Grade Veneer. R. C. Raymond, Douglas Fir Plywood Association. The objective of this study was to find out what the veneer requirements should be if the industry should go to an all-exterior glue line.

In the experiment the effect of knothole size and burls were evaluated on the basis of bond quality. In Phase I of the work, 5-ply panels were laid up that contained knotholes in one piece of core ranging from one inch up to 3½ inches in diameter. Shear specimens were cut from the areas containing these defects, and were tested according to CS 45–55. The specimens were so kerfed that the core area directly over the knothole in the other piece of core became the shear area. Test results indicated that, as knothole size increased, both percentage of wood failure and shear strength decreased. No reduction was encountered with one-inch diameter knotholes.

Phase II of the work was concerned with the surface quality as affected by defects. Three-ply test panels were sanded to ⅜-inch thickness, and were evaluated for face checking. Results indicated that, as knothole size increased, checking increased. In addition, check width increased over the larger knotholes.

Phase III of the work consists of exposing panels similar to those used in Phase II to the weather. The results are as yet inconclusive.

Accelerated Cyclic Exposure as a Quality Control Tool in Plywood Production. A. H. Rauch and O. F. Campbell Jr., U. S. Plywood Corp. The authors described a machine built by U. S. Plywood for evaluating glue bond quality rapidly.

Plywood side or end trim is cut into 1 by 10 inch specimens and tested. A 6-cycle test that lasts 24 hours has been found satisfactory with samples taken from the top, middle, and bottom panels from a press load. The specimens are evaluated after the 24-hour exposure period. Any visible opening ⅛ inch deep is considered a delamination. Results are converted to percentages and are based on the total inches of exposed glue line. This test procedure has been correlated with CS 45-55 shear specimens. The test procedure is the basis for a practical quality control program for the plywood plant.

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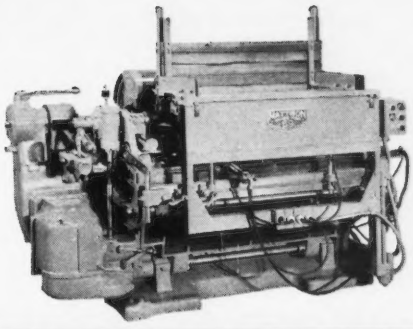

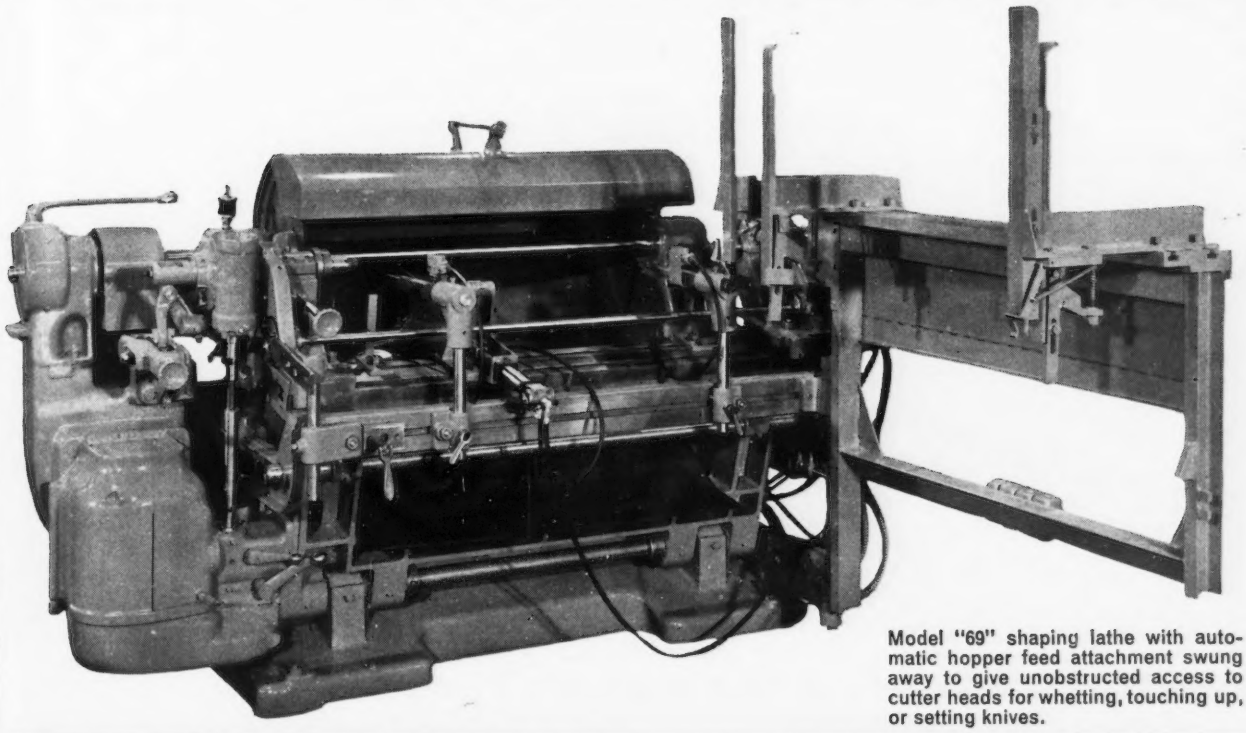

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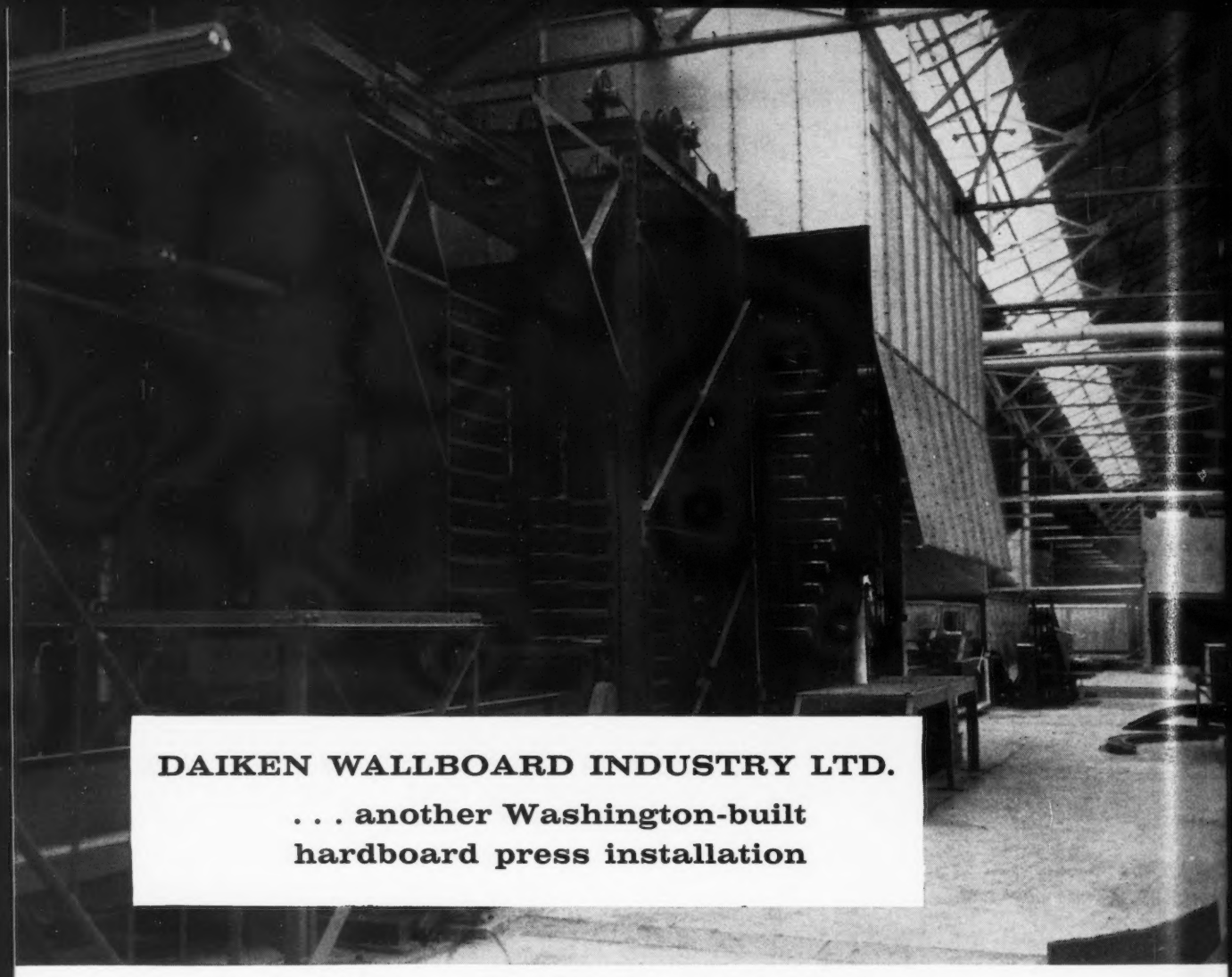

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